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CLAIMS

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[Claim(s)]
[Claim 1] The broadband light amplifier which has at least two wavelength magnification bands, and is characterized by having at least 2 sets of combination of the optical fiber (henceforth, EDF) which doped the optical switch, the excitation light source which enabled it to pour in excitation light according to the light source for excitation and an optical coupler, and the erbium in the light amplifier for the input signal light of the input condition the wavelength band of the lightwave signal inputted is single, and known.
[ input condition ]
[Claim 2] When it has the above-mentioned excitation light source, an optical coupler, and 2 sets of EDF, the EDF concerned The magnification band of the 1st light amplifier constituted using the first combination, The magnification band of the 2nd light amplifier constituted using the combination of the 1st and the 2nd both The broadband light amplifier according to claim 1 characterized by setting the die length of EDF, or said two die length of EDF and dope concentration of an erbium as predetermined so that a predetermined magnification band may optimize, respectively.
[Claim 3] An optical switch makes optical-path connection to the lightwave signal outgoing end of this broadband light amplifier in response to the lightwave signal outputted from the configuration of the 1st light amplifier when amplifying the lightwave signal of the magnification band of the 1st light amplifier, and carries out outgoing radiation to the exterior. In response to the lightwave signal outputted from the configuration of the 1st light amplifier when amplifying the lightwave signal of the magnification band of the 2nd light amplifier, make optical-path connection to the input edge of the 2nd combination of said light source, coupler, and EDF, and the 2nd light amplifier is constituted on the whole. The broadband light amplifier according to claim 1 characterized by making optical-path connection to the lightwave signal outgoing end of this broadband light amplifier in response to the lightwave signal outputted from said 2nd combination, and carrying out outgoing radiation to the exterior.
[Claim 4] The wavelength band of the lightwave signal inputted is single, and are aimed at the input signal light of the input condition which is known. In the broadband adjustable wavelength light source which is equipped with the light amplifier which has at least two wavelength magnification bands, and oscillates and outputs the lightwave signal of the predetermined wavelength in both the wavelength field of the magnification wavelength field of the 1st light amplifier, and the magnification wavelength field of the 2nd light amplifier It has at least 2 sets of combination of the optical fiber (henceforth, EDF) which doped the optical switch, the excitation light source which enabled it to pour in excitation light according to the light source for excitation and an optical coupler, and the erbium. When wavelength which forms a loop formation and is oscillated is made into oscillation wavelength, the passage output of the component of said oscillation wavelength is carried out. the band pass filter which makes predetermined decrease other wavelength components — it is — and this oscillation wavelength — adjustable [ from the outside ] — with an adjustable wavelength optical filter equipped with a controllable means The optical separator with which the input edge of this broadband light amplifier is supplied, and another side outputs to the exterior the output light by which the filter was carried out with this adjustable wavelength optical filter as an output light of the broadband adjustable wavelength light source concerned while dichotomizing and branching, The broadband adjustable wavelength light source characterized by outputting to the exterior by making into the adjustable wavelength light source outgoing radiation light oscillated by the above.
[Claim 5] When the 1st light amplifier is equipped with the 1st optical isolator, the 1st Er addition optical fiber, the 1st excitation light source, and the 2nd optical isolator, In response to the incident light from the outside, pass the 1st optical isolator, and the unnecessary lightwave signal from the outgoing end side of hard flow is intercepted. The 1st Er addition optical fiber is a magnification medium equipped with Er

(Erbium) concentration which amplifies the magnification wavelength field of the 1st light amplifier to predetermined, and die length. The 1st excitation light source is the light source for excitation which supplies the light source for excitation to the 1st Er addition optical fiber through a WDM coupler. It is the broadband light amplifier according to claim 1 which passes as it is, is made to output the lightwave signal with which the 2nd optical isolator is outputted from the 1st Er addition optical fiber, and the unnecessary lightwave signal from hard flow is an isolator equipped with the directivity to intercept, and is characterized by providing the above.

[Claim 6] When the 2nd light amplifier is equipped with the 2nd excitation light source, the 2nd Er addition optical fiber, and the 3rd optical isolator, The 2nd excitation light source is the light source for excitation which supplies the light source for excitation to the 2nd Er addition optical fiber through a WDM coupler. The 2nd Er addition optical fiber is a magnification medium equipped with Er concentration which amplifies the magnification wavelength field of the 2nd light amplifier to predetermined with the 1st Er addition optical fiber, and die length. It is the broadband light amplifier according to claim 1 which passes as it is, is made to output the lightwave signal with which the 3rd optical isolator is outputted from the 2nd Er addition optical fiber, and the unnecessary lightwave signal from hard flow is an isolator equipped with the directivity to intercept, and is characterized by providing the above.

[Claim 7] When the 2nd light amplifier is equipped with the 2nd excitation light source, the 2nd Er addition optical fiber, the 3rd excitation light source, and the 3rd optical isolator, The 2nd excitation light source and the 3rd excitation light source are the light sources for excitation which supply the light source for excitation to the 2nd Er addition optical fiber through a WDM coupler. The 2nd Er addition optical fiber is a magnification medium equipped with Er concentration which amplifies the magnification wavelength field of the 2nd light amplifier to predetermined with the 1st Er addition optical fiber, and die length. It is the broadband light amplifier according to claim 1 which passes as it is, is made to output the lightwave signal with which the 3rd optical isolator is outputted from the 2nd Er addition optical fiber, and the unnecessary lightwave signal from hard flow is an isolator equipped with the directivity to intercept, and is characterized by providing the above.

[Claim 8] It is the broadband light amplifier according to claim 5 which the series connection of each component with which the 1st light amplifier is equipped is carried out, and is characterized by the arrangement sequence from the input side of a lightwave signal being the 1st optical isolator, the 1st Er addition optical fiber, the 1st excitation light source, and the arrangement sequence of the 2nd optical isolator.

[Claim 9] It is the broadband light amplifier according to claim 5 which the series connection of each component with which the 1st light amplifier is equipped is carried out, and is characterized by the arrangement sequence from the input side of a lightwave signal being the 1st optical isolator, the 1st excitation light source, the 1st Er addition optical fiber, and the arrangement sequence of the 2nd optical isolator.

[Claim 10] It is the broadband light amplifier according to claim 6 which the series connection of each component with which the 2nd light amplifier is equipped is carried out, and is characterized by the arrangement sequence from the input side of a lightwave signal being the 1st light amplifier, the 2nd excitation light source, the 2nd Er addition optical fiber, and the arrangement sequence of the 3rd optical isolator.

[Claim 11] It is the broadband light amplifier according to claim 6 which the series connection of each component with which the 2nd light amplifier is equipped is carried out, and is characterized by the arrangement sequence from the input side of a lightwave signal being the 1st light amplifier, the 2nd Er addition optical fiber, the 2nd excitation light source, and the arrangement sequence of the 3rd optical isolator.

[Claim 12] It is the broadband light amplifier according to claim 7 which the series connection of each component with which the 2nd light amplifier is equipped is carried out, and is characterized by the arrangement sequence from the input side of a lightwave signal being the 1st light amplifier, the 2nd excitation light source, the 2nd Er addition optical fiber, the 3rd excitation light source, and the arrangement sequence of the 3rd optical isolator.

[Claim 13] In the light amplifier for the input signal light of the input condition the wavelength band of the lightwave signal which has at least two wavelength magnification bands, and is inputted is single, and known [ input condition ] An optical switch and the excitation light source which enabled it to pour in excitation light according to the light source for excitation, It has at least 2 sets of light amplifiers amplified and outputted to predetermined based on the combination of an optical coupler and the optical fiber (Following EDF and name) which doped the erbium. The multiplexing/demultiplexing coupler which carries out the

passage output of the magnification signal light and ASE light which pour in the excitation light in this light amplifier that amplifies the magnification band of long wavelength, and are outputted from this EDF The broadband light amplifier characterized by what is been the multiplexing/demultiplexing coupler which can carry out filter clearance so that the amount of [ of a wavelength band shorter than the wavelength band which the light amplifier concerned amplifies in the wavelength band of ASE light ] ASE Mitsunari may not superimpose on a signal output.
[Claim 14] In the light amplifier for the input signal light of the input condition whose wavelength band of the lightwave signal which has at least two wavelength magnification bands, and is inputted is known An optical switch and the excitation light source which enabled it to pour in excitation light according to the light source for excitation, It has at least 2 sets of light amplifiers amplified and outputted to predetermined based on the combination of an optical coupler and the optical fiber (Following EDF and name) which doped the erbium. When EDF of a latter light amplifier receives the magnification signal light and ASE light from a light amplifier of the preceding paragraph, and excitation light is poured in to the EDF concerned and the magnification band of long wavelength is amplified, the optical path which outputs the magnification signal light and ASE light which were amplified from the output side of this EDF out of the light amplifier concerned — receiving — a long wave — the broadband light amplifier characterized by what it inserts and has for the light filter component which decreases parts for ASE Mitsunari other than merit's magnification band to predetermined passage inhibition or predetermined.
[Claim 15] A light filter component is a broadband light amplifier according to claim 14 characterized by the thing which carries out passage inhibition of the predetermined wavelength band selectively in those for ASE Mitsunari, and can pour in excitation light to this EDF, and which it is a WDM coupler.
[Claim 16] Impregnation of the excitation light to EDF which has in the light amplifier which amplifies the magnification band of long wavelength is a broadband light amplifier according to claim 13 or 14 characterized by what is considered as back excitation or bidirectional excitation.
[Claim 17] Impregnation of the excitation light to EDF which has in the light amplifier connected to the preceding paragraph of the light amplifier which amplifies the magnification band of long wavelength is a broadband light amplifier according to claim 13 or 14 characterized by what is considered as front excitation, back excitation, or bidirectional excitation.
[Claim 18] It is the broadband light amplifier according to claim 13 or 14 which a short wavelength magnification band is a C band, and is characterized by what a long wavelength magnification band is an L band.
[Claim 19] The long wavelength magnification band which the short wavelength magnification band which the 1st light amplifier with which the preceding paragraph is equipped amplifies when it has the 1st two light amplifier and the 2nd light amplifier as a broadband light amplifier is a C band, and is amplified with the 2nd light amplifier is a broadband light amplifier according to claim 13 or 14 characterized by what is been an L band.
[Claim 20] In the light amplifier which the input signal light inputted from the outside is the lightwave signal of 2 wavelength bands of the 1st wave band and the 2nd wave band, and is amplified and outputted to predetermined in response to the input signal light concerned The 1st erbium dope fiber equipped with the dope concentration conditions and fiber length of the erbium which can be amplified to predetermined for the 1st wave band (the 1st EDF and name), As opposed to the erbium dope fiber equipped with the dope concentration conditions and fiber length of the erbium which can be amplified to predetermined for the 2nd wave band The 2nd erbium dope fiber used as the remaining erbium dope fibers which deducted the fiber conditions of the 1st EDF (the 2nd EDF and name), The 1st light amplifier which amplifies the 1st wave band to predetermined based on the 1st EDF, and contains the component in which an output is possible in response to the input signal light from the outside, The 2nd optical amplification section which amplifies the 2nd wave band to predetermined based on the series connection of the 1st EDF and the 2nd EDF, and builds in the component in which an output is possible in response to the magnification signal light and spontaneous emmision light (ASE light) which are outputted from the 1st light amplifier, In amplifying and outputting the 1st wave band to the 1st, it makes optical-path connection of the outgoing end of the 1st light amplifier to the external outgoing end of this broadband light amplifier. The optical switch which performs the optical-path change which makes optical-path connection of the outgoing end of the 1st light amplifier to the input edge of the 2nd optical amplification section in amplifying and outputting the 2nd wave band to the 2nd, and makes optical-path connection of the outgoing end of the 2nd optical amplification section to the external outgoing end of this broadband light amplifier, The broadband light amplifier characterized by providing the above.
[Claim 21] The 2nd optical amplification section is a broadband light amplifier according to claim 20

characterized by what it has further for the light filter component which carries out filter clearance of the parts for ASE Mitsunari other than the 2nd wave band predetermined when amplifying and outputting the 2nd wave band to predetermined.

[Claim 22] It is the broadband light amplifier characterized by what this long wave length band is amplified for based on the optical-path connection configuration to which magnification of a long wave length band carried out the series connection of the 1st light amplifier and the 2nd optical amplification section in the light amplifier of a configuration of having the 1st light amplifier which amplifies a short wavelength band, and the 2nd optical amplification section which amplifies a long wave length band rather than said short wavelength band.

[Claim 23] When the 2nd light amplifier is equipped with the 1st light amplifier, 2nd excitation light source, 2nd Er addition optical fiber, and 3rd optical isolator, The 1st light amplifier is equipped with the 1st optical isolator, the 1st Er addition optical fiber, the 1st excitation light source, and the 2nd optical isolator. In response to the incident light from the outside, pass the 1st optical isolator, and the unnecessary lightwave signal from the outgoing end side of hard flow is intercepted. The 1st Er addition optical fiber is a magnification medium equipped with Er (Erbium) concentration which amplifies the magnification wavelength field of the 1st light amplifier to predetermined, and die length. The 1st excitation light source is the light source for excitation which supplies the light source for excitation to the 1st Er addition optical fiber through a WDM coupler. Pass as it is and the lightwave signal with which the 2nd optical isolator is outputted from the 1st Er addition optical fiber is made to output. The unnecessary lightwave signal from hard flow is what is an isolator equipped with the directivity to intercept. The 2nd excitation light source is the light source for excitation which supplies the light source for excitation to the 2nd Er addition optical fiber through a WDM coupler. The 2nd Er addition optical fiber is a magnification medium equipped with Er concentration which amplifies the magnification wavelength field of the 2nd light amplifier to predetermined with the 1st Er addition optical fiber, and die length. It is the broadband light amplifier according to claim 1 which passes as it is, is made to output the lightwave signal with which the 3rd optical isolator is outputted from the 2nd Er addition optical fiber, and the unnecessary lightwave signal from hard flow is an isolator equipped with the directivity to intercept, and is characterized by providing the above.

[Claim 24] When the 2nd light amplifier is equipped with the 1st light amplifier, 2nd excitation light source, 2nd Er addition optical fiber, 3rd excitation light source, and 3rd optical isolator, The 1st light amplifier is equipped with the 1st optical isolator, the 1st Er addition optical fiber, the 1st excitation light source, and the 2nd optical isolator. In response to the incident light from the outside, pass the 1st optical isolator, and the unnecessary lightwave signal from the outgoing end side of hard flow is intercepted. The 1st Er addition optical fiber is a magnification medium equipped with Er (Erbium) concentration which amplifies the magnification wavelength field of the 1st light amplifier to predetermined, and die length. The 1st excitation light source is the light source for excitation which supplies the light source for excitation to the 1st Er addition optical fiber through a WDM coupler. Pass as it is and the lightwave signal with which the 2nd optical isolator is outputted from the 1st Er addition optical fiber is made to output. The unnecessary lightwave signal from hard flow is what is an isolator equipped with the directivity to intercept. The 2nd excitation light source and the 3rd excitation light source are the light sources for excitation which supply the light source for excitation to the 2nd Er addition optical fiber through a WDM coupler. The 2nd Er addition optical fiber is a magnification medium equipped with Er concentration which amplifies the magnification wavelength field of the 2nd light amplifier to predetermined with the 1st Er addition optical fiber, and die length. It is the broadband light amplifier according to claim 1 which passes as it is, is made to output the lightwave signal with which the 3rd optical isolator is outputted from the 2nd Er addition optical fiber, and the unnecessary lightwave signal from hard flow is an isolator equipped with the directivity to intercept, and is characterized by providing the above.

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[Translation done.]

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DETAILED DESCRIPTION

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[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to a broadband light amplifier and the broadband adjustable wavelength light source. It is related with the broadband adjustable wavelength light source using the broadband light amplifier and this whose magnification is enabled for the known wavelength in the broadband wavelength especially crossed to both the bands of 1.55-micrometer band (1.53 micrometers - 1.565 micrometers: C band) and 1.58-micrometer band (1.565 micrometers - 1.60 micrometers: L band).
[0002]
[Description of the Prior Art] The conventional technique is explained below with reference to the broadband light amplifier of drawing 1 . in addition — as the reference works of the broadband light amplifier crossed to both the bands of a C band and an L band — JP,10-229238,A — it is — moreover, reference:Electron Lett.33 and p — 710 and 1997 There is M.Yamadaet.al.
[0003] The important section configuration of a broadband light amplifier changes with the C band light amplifier 100, the L band light amplifier 200, a splitter, and a multiplexing vessel, as shown in drawing 1 . One C band light amplifier 100 changes with the 1st optical isolator 11, the 1st Er addition optical fiber 21, the 1st excitation light source 31, WDM coupler 31c, and the 2nd optical isolator 12. The L band light amplifier 200 of another side changes with the 3rd optical isolator 13, the 2nd excitation light source 32, WDM coupler 32c, the 2nd Er addition optical fiber 22, the 3rd excitation light source 33, WDM coupler 33c, and the 4th optical isolator 14. As for a splitter, the WDM coupler 61 is used as an example, and, as for a multiplexing machine, the WDM coupler 62 is used as an example.
[0004] To the WDM (wavelength division multiplex: WavelengthDivision Multiplexing) coupler 61 which is a splitter, incidence of the 10s of the incident light is carried out, it dichotomizes by this, and distribution supply is carried out to the 1st optical isolator 11 and the 3rd optical isolator 13. In addition, other splitters may be used instead of a WDM coupler, and there is also an example of a configuration using an optical switch.
[0005] One C band light amplifier 100 is explained. The 1st optical isolator 11 intercepts the light which passes to hard flow, carries out the passage output of the 10s of the incident light distributed above, and supplies it to the 1st Er addition optical fiber 21. Undesired signals, such as excitation light used as the hard flow from an outgoing end side, are intercepted.
[0006] The 1st Er addition optical fiber (erbium dope fiber) 21 is formed in the conditions of fiber length optimized although it is used as a magnification medium and a C band is amplified. For example, 20m Er addition optical fiber is used as fiber length. The excitation light source from the 1st excitation light source 31 is received through WDM coupler 31c, and 21s of lightwave signals which amplified 11s of dozens of dB input lightwave signals using the laser operation of a rare earth addition optical fiber is supplied to the 2nd optical isolator 12.
[0007] The 1st excitation light source 31 and WDM coupler 31c generate and supply the excitation light source which makes a request excite and amplify the 1st Er addition optical fiber 21.
[0008] The light which passes to hard flow like the above is intercepted, dozens of 21s dB, for example, the lightwave signal amplified 20dB or more, is outputted for a C band above, and the 2nd optical isolator 12 also prevents the backlight from an output side.
[0009] The L band light amplifier 200 of another side is the same as that of the above. However, the 2nd Er addition optical fiber 22 uses what was formed in the conditions of the fiber length corresponding to an L band. For example, 120m Er addition optical fiber is used as fiber length. It has the 2nd excitation light source 32 between the 3rd optical isolator 13 and the 2nd Er addition optical fiber 22, and the 3rd

excitation light source 33 is considered as the configuration, for example, amplify [ 20dB or more ], an L band, in preparation for between the 2nd Er addition optical fiber 22 and the 4th optical isolator 14. [ dozens of ] In addition, in order for the 2nd Er addition optical fiber 22 to amplify an L band, in order to excite the fiber of this long picture, bidirectional excitation or excitation by high power is required [ Er addition optical fiber of a no less than 120m long picture is required, and ]. In drawing 1 R> 1, it is the example of a configuration considered as bidirectional excitation.

[0010] The WDM coupler 62 is used as a multiplexing machine, and is outputted as 62s of outgoing radiation light which multiplexed both in response to 12s of lightwave signals of the C band which is outputted from the above-mentioned C band light amplifier 100 and which was amplified dozens of dB, and 13s of lightwave signals of the L band which is outputted from the above-mentioned L band light amplifier 200 and which was amplified dozens of dB. In addition, other synthetic vessels may be used instead of a WDM coupler. Moreover, there is also an example of a configuration using an optical switch.

[0011] As shown in the example of a configuration of drawing 1 , optical amplification of the signal light which passed the optical isolators 11 and 13 with which the common broadband light amplifier crossed to both the bands of a C band and an L band restricts the travelling direction of light to an one direction is carried out to predetermined with corresponding Er addition optical fibers 21 and 22 by the excitation light from the excitation light sources 31, 32, and 33 inputted through the WDM couplers 31c, 32c, and 33c. The amplified lightwave signal is respectively outputted through optical isolators 12 and 13. Here, moving from a magnification band to a long wavelength side gradually is known by being able to control by excitation light reinforcement of the excitation light source the band by which optical amplification is carried out with the fiber length of Er addition optical fibers 21 and 22, and lengthening Er addition optical fiber length especially.

[0012]

[Problem(s) to be Solved by the Invention] As the above-mentioned explanation was given, in order to perform broadband magnification crossed to both the bands of a C band and an L band, much excitation light sources are needed. Moreover, as a result of an optical isolator is respectively needed for the I/O both sides of the both sides of a C band and an L band and a splitter's being needed, there is a difficulty that there is also an insertion loss of light and many numbers of optical components tend to become expensive. Furthermore, there is a difficulty that 120m length is needed, respectively, by 20m length and the object for L band magnification for example, by the object for C band magnification also about Er addition optical fiber. On the other hand, it is that 11s of input lightwave signals is used on known wavelength in most cases. Then, the wavelength band of input light is known, and the technical problem which this invention tends to solve is offering the broadband adjustable wavelength light source using the broadband light amplifier and this which amplify this to predetermined, when it is in a single band.

[0013]

[Means for Solving the Problem] Drawing 2 shows the solution means concerning this invention. in order to solve the above-mentioned technical problem , it have at least two wavelength magnification bands , and the wavelength band of the lightwave signal input be single , and it be the broadband light amplifier characterize by to have at least 2 sets of combination of the optical fiber ( henceforth , EDF ) which doped the optical switch , the excitation light source which enabled it to pour in excitation light according to the light source for excitation and an optical coupler , and the erbium in the light amplifier for the input signal light of the input condition which be known . According to the above-mentioned invention, the broadband light amplifier which the wavelength band of input light is known, and can constitute the cheaper equipment which amplifies this to predetermined when it is in a single band is realizable.

[0014] When it has the above-mentioned excitation light source, an optical coupler, and 2 sets of EDF, moreover, **** EDF The magnification band of the 1st light amplifier constituted using the first combination, There is an above-mentioned broadband light amplifier characterized by setting the die length of EDF, or said two die length of EDF and dope concentration of an erbium as predetermined so that a predetermined magnification band may optimize the magnification band of the 2nd light amplifier constituted using the combination of the 1st and the 2nd both, respectively.

[0015] Moreover, the above-mentioned optical switch makes optical-path connection to the lightwave signal outgoing end of this broadband light amplifier in response to the lightwave signal outputted from the configuration of the 1st light amplifier when amplifying the lightwave signal of the magnification band of the 1st light amplifier, and carries out outgoing radiation to the exterior. In response to the lightwave signal outputted from the configuration of the 1st light amplifier when amplifying the lightwave signal of the magnification band of the 2nd light amplifier, make optical-path connection to the input edge of the 2nd combination of said light source, coupler, and EDF, and the 2nd light amplifier is constituted on the whole.

There is an above-mentioned broadband light amplifier characterized by making optical-path connection to the lightwave signal outgoing end of this broadband light amplifier in response to the lightwave signal outputted from said 2nd combination, and carrying out outgoing radiation to the exterior.

[0016] Drawing 3 shows the solution means concerning this invention. In the broadband adjustable wavelength light source which oscillates and outputs the lightwave signal of the predetermined wavelength in both the wavelength field of the magnification wavelength field of the 1st light amplifier, and the magnification wavelength field of the 2nd light amplifier in order to solve the above-mentioned technical problem When the wavelength which possesses the above-mentioned broadband light amplifier, forms a loop formation, and is oscillated is called oscillation wavelength, Said oscillation wavelength is the predetermined wavelength in both the wavelength field of a C band wavelength field and an L band wavelength field. It is the band pass filter which carries out the passage output of the component of said oscillation wavelength, and makes predetermined decrease other wavelength components, or carries out passage inhibition. The adjustable wavelength optical filter 70 equipped with a controllable means is provided. and the above-mentioned oscillation wavelength which is the main wavelength of said band pass filter — adjustable [ from the outside ] — While the output light by which the filter was carried out was dichotomized and branched with the adjustable wavelength optical filter 70, supply the input edge of the above-mentioned broadband light amplifier, and an oscillation loop formation is made to form. There is the broadband adjustable wavelength light source characterized by for another side possessing the optical separator 85 outputted to the exterior as an output light of the broadband adjustable wavelength light source concerned, and outputting it to the exterior by making into the adjustable wavelength light source 85s of outgoing radiation light which was made to form a feedback loop with the above component, and was oscillated.

[0017] Figs. 2 - 13 show the solution means concerning this invention. Moreover, when the 1st light amplifier 120 is equipped with the 1st optical isolator 11, the 1st Er addition optical fiber 21, the 1st excitation light source 31, and the 2nd optical isolator 12, The 1st optical isolator 11 is passed in response to 10s of incident light from the outside. The unnecessary lightwave signal from the outgoing end side of hard flow is intercepted, and the 1st Er addition optical fiber 21 is a magnification medium equipped with Er (Erbium) concentration which amplifies the magnification wavelength field of the 1st light amplifier to predetermined, and die length. The 1st excitation light source 31 is the light source for excitation which supplies the light source for excitation which makes predetermined amplify a C band wavelength field through WDM coupler 31c to the 1st Er addition optical fiber 21. Pass as it is and the 2nd optical isolator 12 makes the lightwave signal outputted from the 1st Er addition optical fiber 21 output. The unnecessary lightwave signal from hard flow is an isolator equipped with the directivity to intercept, and there is an above-mentioned broadband light amplifier characterized by providing the above in the C band light amplifier 120.

[0018] Figs. 2 - 6, 9 - 11 show the solution means concerning this invention. Moreover, when the component 220 of the 2nd light amplifier 320 is equipped with the 2nd excitation light source 32, the 2nd Er addition optical fiber 22, and the 3rd optical isolator 13, The 2nd excitation light source 32 is the light source for excitation which supplies the light source for excitation which makes predetermined amplify an L band wavelength field through WDM coupler 32c to the 2nd Er addition optical fiber 22. The 2nd Er addition optical fiber 22 is a magnification medium equipped with Er concentration which amplifies the magnification wavelength field of the 2nd light amplifier to predetermined with the 1st Er addition optical fiber 22, and die length. Pass as it is and the 3rd optical isolator 13 makes the lightwave signal outputted from the 2nd Er addition optical fiber 22 output, and the unnecessary lightwave signal from hard flow is an isolator equipped with the directivity to intercept, and has the above-mentioned broadband light amplifier characterized by providing the above.

[0019] Drawing 7, drawing 8, drawing 12, and drawing 13 show the solution means concerning this invention. Moreover, when the component 220 of the 2nd light amplifier 320 is equipped with the 2nd excitation light source 32, the 2nd Er addition optical fiber 22, the 3rd excitation light source 33, and the 3rd optical isolator 13, The 2nd excitation light source 32 and the 3rd excitation light source 33 the light source for excitation which makes predetermined amplify an L band wavelength field to the 2nd Er addition optical fiber 22 WDM coupler 32c, It is the light source for excitation supplied through 33c, and the 2nd Er addition optical fiber 22 is a magnification medium equipped with Er concentration which amplifies the magnification wavelength field of the 2nd light amplifier to predetermined with the 1st Er addition optical fiber 22, and die length. Pass as it is and the 3rd optical isolator 13 makes the lightwave signal outputted from the 2nd Er addition optical fiber 22 output, and the unnecessary lightwave signal from hard flow is an isolator equipped with the directivity to intercept, and has the above-mentioned broadband light amplifier characterized by

providing the above.
[0020] Drawing 2, drawing 5, and drawing 7 show the solution means concerning this invention. Moreover, the series connection of each component with which the 1st light amplifier 120 of **** is equipped is carried out, and the arrangement sequence from the input side of a lightwave signal has the above-mentioned broadband light amplifier characterized by being the 1st optical isolator 11, the 1st Er addition optical fiber 21, the 1st excitation light source 31, and the arrangement sequence of the 2nd optical isolator 12. Drawing 4, drawing 6, and drawing 8 show the solution means concerning this invention. Moreover, the series connection of each component with which the 1st light amplifier 120 of **** is equipped is carried out, and the arrangement sequence from the input side of a lightwave signal has the above-mentioned broadband light amplifier characterized by being the 1st optical isolator 11, the 1st excitation light source 31, the 1st Er addition optical fiber 21, and the arrangement sequence of the 2nd optical isolator 12.
[0021] Drawing 2 and drawing 4 show the solution means concerning this invention. Moreover, the series connection of each component with which the 2nd light amplifier 320 of **** is equipped is carried out, and the arrangement sequence from the input side of a lightwave signal has the above-mentioned broadband light amplifier characterized by being the 1st light amplifier, the 2nd excitation light source 32, the 2nd Er addition optical fiber 22, and the arrangement sequence of the 3rd optical isolator 13. Drawing 5 and drawing 6 show the solution means concerning this invention. Moreover, the series connection of each component with which the 2nd light amplifier 320 of **** is equipped is carried out, and the arrangement sequence from the input side of a lightwave signal has the above-mentioned broadband light amplifier characterized by being the 1st light amplifier, the 2nd Er addition optical fiber 22, the 2nd excitation light source 32, and the arrangement sequence of the 3rd optical isolator 13. Drawing 7 and drawing 8 show the solution means concerning this invention. Moreover, the series connection of each component with which the 2nd light amplifier 320 of **** is equipped is carried out, and the arrangement sequence from the input side of a lightwave signal has the above-mentioned broadband light amplifier characterized by being the 1st light amplifier, the 2nd excitation light source 32, the 2nd Er addition optical fiber 22, the 3rd excitation light source 33, and the arrangement sequence of the 3rd optical isolator 13.
[0022] In the light amplifier for the input signal light of the input condition the wavelength band of the lightwave signal which has at least two wavelength magnification bands, and is inputted in order to solve the above-mentioned technical problem is single, and known [ input condition ] An optical switch and the excitation light source which enabled it to pour in excitation light according to the light source for excitation, It has at least 2 sets of light amplifiers amplified and outputted to predetermined based on the combination of an optical coupler and the optical fiber (Following EDF and name) which doped the erbium. The multiplexing/demultiplexing coupler (for example, WDM coupler) which carries out the passage output of the magnification signal light and ASE light which pour in the excitation light in the above-mentioned light amplifier which amplifies the magnification band of long wavelength, and are outputted from Above EDF There is a broadband light amplifier characterized by what is been the multiplexing/demultiplexing coupler which can carry out filter clearance so that the amount of [ of a wavelength band shorter than the wavelength band which the light amplifier concerned amplifies in the wavelength band of ASE light ] ASE Mitsunari may not superimpose on a signal output.
[0023] Drawing 15 and drawing 17 show the solution means concerning this invention. In the light amplifier for the input signal light of the input condition whose wavelength band of the lightwave signal which has at least two wavelength magnification bands, and is inputted in order to solve the above-mentioned technical problem is known An optical switch and the excitation light source which enabled it to pour in excitation light according to the light source for excitation, It has at least 2 sets of light amplifiers amplified and outputted to predetermined based on the combination of an optical coupler and the optical fiber (Following EDF and name) which doped the erbium. When EDF of a latter light amplifier receives the magnification signal light and ASE light from a light amplifier of the preceding paragraph, and excitation light is poured in to the EDF concerned and the magnification band of long wavelength is amplified, the optical path which outputs the magnification signal light and ASE light which were amplified from the output side of Above EDF out of the light amplifier concerned — receiving — a long wave — there is a broadband light amplifier characterized by what it inserts and has for the light filter component which decreases parts for ASE Mitsunari other than merit's magnification band to predetermined passage inhibition or predetermined.
[0024] Moreover, there is an above-mentioned broadband light amplifier characterized by the thing which carries out passage inhibition of the predetermined wavelength band selectively in those for ASE Mitsunari, and can pour in excitation light to Above EDF as one mode of the above-mentioned light filter component, and which it is the WDM coupler 40.

[0025] Moreover, there is an above-mentioned broadband light amplifier characterized by what is considered as back excitation or bidirectional excitation as one mode of impregnation of the excitation light to EDF which has in the light amplifier which amplifies the magnification band of above-mentioned long wavelength. Moreover, there is an above-mentioned broadband light amplifier characterized by what is considered as front excitation, back excitation, or bidirectional excitation as one mode of impregnation of the excitation light to EDF which has in the light amplifier connected to the preceding paragraph of the light amplifier which amplifies the magnification band of above-mentioned long wavelength.
[0026] moreover, the above-mentioned short wavelength magnification band — a C band — it is — the above — a long wave — a long magnification band has the above-mentioned broadband light amplifier characterized by what is been an L band. Moreover, when it has the 1st two light amplifier and the 2nd light amplifier as an above-mentioned broadband light amplifier, the short wavelength magnification band which the 1st light amplifier with which the preceding paragraph is equipped amplifies is a C band, and the long wavelength magnification band amplified with the 2nd light amplifier has the above-mentioned broadband light amplifier characterized by what is been an L band.
[0027] Drawing 2, Figs. 4 - 8, drawing 15, and drawing 18 show the solution means concerning this invention. When the input signal light inputted from the outside is the lightwave signal of 2 wavelength bands of the 1st wave band and the 2nd wave band in order to solve the above-mentioned technical problem, and it is the input of a known lightwave signal with said single lightwave signal, In the light amplifier amplified and outputted to predetermined in response to the input signal light concerned When it assumes that the 1st wave band (for example, C band) is a wavelength band shorter than the 2nd wave band (for example, L band), The 1st erbium dope fiber (the 1st EDF and name) equipped with the dope concentration conditions and fiber length of the erbium which can be amplified to predetermined for the 1st wave band is provided. As opposed to the erbium dope fiber equipped with the dope concentration conditions and fiber length of the erbium which can be amplified to predetermined for the 2nd wave band The 2nd erbium dope fiber (the 2nd EDF and name) used as the remaining erbium dope fibers which deducted the fiber conditions of the 1st EDF is provided. In response to the input signal light from the outside, the 1st light amplifier 120 which amplifies the 1st wave band to predetermined based on the 1st EDF, and contains the component in which an output is possible is provided. The magnification signal light and spontaneous emmision light (ASE light) which are outputted from the 1st light amplifier 120 are received. The 2nd optical amplification section 220 which amplifies the 2nd wave band to predetermined based on the series connection of the 1st EDF and the 2nd EDF, and builds in the component in which an output is possible is provided. In amplifying and outputting the 1st wave band to the 1st, it makes optical-path connection of the outgoing end of the 1st light amplifier 120 to the external outgoing end of this broadband light amplifier. In amplifying and outputting the 2nd wave band to the 2nd, it makes optical-path connection of the outgoing end of the 1st light amplifier 120 to the input edge of the 2nd optical amplification section 220. And there is a broadband light amplifier characterized by providing the optical switch 50 which can perform the optical-path change which makes optical-path connection of the outgoing end of the 2nd optical amplification section 220 to the external outgoing end of this broadband light amplifier, and providing the above.
[0028] Drawing 15 and drawing 17 show the solution means concerning this invention. Moreover, it is the light filter component (for example, there is an above-mentioned broadband light amplifier characterized by what it has further the WDM coupler 40 equipped with the filter structure which carries out passage inhibition below of a C band wavelength field for.) which carries out filter clearance of the parts for ASE Mitsunari other than the 2nd wave band predetermined when amplifying and outputting the 2nd wave band to predetermined as one mode of the optical amplification section 220 above-mentioned [ 2nd ].
[0029] In the light amplifier of a configuration of having the component 220 of the 1st light amplifier 120 which amplifies a short wavelength band, and the 2nd light amplifier 320 which amplifies a long wave length band rather than said short wavelength band, in order to solve the above-mentioned technical problem Magnification of a long wave length band amplifies the above-mentioned long wave length band based on the optical-path connection configuration which carried out the series connection of the 1st light amplifier 120 and the 2nd optical amplification section 220. There is a broadband light amplifier characterized by what the series connection of both the erbiums dope fiber with which the 1st light amplifier 120 and the 2nd optical amplification section 220 are equipped is carried out, and it becomes possible for a long wave length band to amplify it to predetermined especially more.
[0030] In addition, an invention-in-this-application means is good also as other usable configuration means, combining suitably each element means [ in / by request / the above-mentioned solution means ].
[0031]

[Embodiment of the Invention] An example of the gestalt of the operation which applied this invention to below is explained referring to a drawing. Moreover, a claim is not limited according to the content of explanation of the gestalt of the following operations, and neither the element currently explained with the gestalt of operation nor connection relation is necessarily still more indispensable for a solution means.

[0032] The broadband light amplifier of this invention is explained below with reference to drawing 2 and drawing 14 . In addition, the component corresponding to a configuration attaches the same sign conventionally, and explanation of the overlapping part is omitted. The important section configuration of a broadband light amplifier changes with the C band light amplifier 120, the component 220 of the L band light amplifier 320, and an optical switch 50. This deletes the WDM coupler 61 for dichotomy, and the WDM coupler 62 for multiplexing to the conventional configuration, further, deletes one isolator, the one excitation light source, and WDM coupler, and changes with the configuration of having added the optical switch 50, instead. The broadband light amplifier of this invention has at least two wavelength magnification bands, and the wavelength band of 11s of input lightwave signals is single, and it is the equipment configuration which made it the prerequisite to be inputted by known. Therefore, when 11s of input lightwave signals is the wavelength of a C band band, a C band band is amplified with the C band light amplifier 120, and it outputs as it is, and when 11s of input lightwave signals is the wavelength of an L band band, an L band band is amplified and outputted to the 1st the 2nd with the component 220 of the C band light amplifier 120 and the L band light amplifier 320.

[0033] The component of one C band light amplifier 120 changes with the 1st optical isolator 11, the 1st Er addition optical fiber 21, the 1st excitation light source 31, WDM coupler 31c, and the 2nd optical isolator 12. The component of the L band light amplifier 220 of another side changes with the 2nd excitation light source 32, WDM coupler 32c, the 2nd Er addition optical fiber 22, and the 3rd optical isolator 13.

[0034] An optical switch 50 carries out the series connection of the 1st gestalt of operation which amplifies and outputs a C band band with the C band light amplifier 120, and the component 220 of the C band light amplifier 120 and the L band light amplifier 320, it is an optical-path change-over switch changed to the 2nd gestalt of operation which amplifies and outputs an L band band, and change-over control is carried out by the control from the outside.

[0035] In the 1st gestalt of operation, in response to 10s of incident light of a C band band, an optical switch 50 is passed (refer to drawing 2 R>2A), and 12s of lightwave signals which amplified dozens of dB or more, for example, 20dB, to predetermined with the C band light amplifier 120 (refer to drawing 14 A) is outputted as 51s of outgoing radiation light. Here, the fiber length of the 1st Er addition optical fiber 21 is the same as usual, for example, 20m Er addition optical fiber is used.

[0036] In the 2nd gestalt of operation, it is first intermingled and outputted with the C band light amplifier 120 in response to 10s of incident light of an L band band with 10s of incident light of an L band band, and the spontaneous emmision light (ASE light) of the C band band which is excited with the 1st Er addition optical fiber 21, and is outputted. This passes an optical switch 50 (refer to drawing 2 B), and is supplied to the component 220 of the L band light amplifier 320. Next, as for the fiber length of the 2nd Er addition optical fiber 22, unlike the former, in the component 220 of the L band light amplifier 320, Er addition optical fiber of 120m-20m= 100m length is used. And in response to 52s of lightwave signals with which the above-mentioned ASE light and 10s of incident light were intermingled, by exciting the 2nd Er addition optical fiber 22 by the 2nd excitation light source 32 and ASE light, the lightwave signal of an L band band passes an optical switch 50 to predetermined ( drawing 2 C **), and 22s of lightwave signals which amplified dozens of dB or more, for example, 20dB, (refer to drawing 14 B) is outputted to it as 51s of outgoing radiation light. As mentioned above, when the fiber length of the 1st Er addition optical fiber 21 is set to A and the fiber length of the 2nd Er addition optical fiber 22 is set to B, the total length adding the die length (A+B) of two Er addition optical fibers 21 and 22 becomes die length required to amplify an L band. In the above-mentioned numerical example, Er addition optical fibers of 20m length are reducible. Therefore, the advantage which can do cheaply the 2nd Er addition optical fiber 22 made short is acquired. Furthermore, as a result of exciting the 2nd Er addition optical fiber 22 by the ASE light outputted with the C band light amplifier 120, and the 2nd excitation light source 32 of the component 220 of the L band light amplifier 320 according to the above-mentioned configuration, the advantage that the 2nd excitation light source 32 can be managed with little excitation light source is acquired.

[0037] According to the configuration of drawing 2 mentioned above, 51s of outgoing radiation light with which a part for a part for C band Mitsunari and L band Mitsunari was amplified by predetermined is obtained by having considered as the configuration which carries out the series connection of the component 220 of the C band light amplifier 120 and the L band light amplifier 320, and amplifies it. Consequently, the advantage on which the same broadband magnification function as usual is realized

cheaply is acquired. Furthermore, the WDM coupler 61 for dichotomy in the component shown in drawing 1 R> 1, the WDM coupler 62 for multiplexing, and one isolator, excitation light source and WDM coupler are deleted, and as a result of realizing with the configuration which forms an optical switch 50 instead, the big advantage which equipment can constitute more cheaply is acquired.
[0038] Next, the broadband adjustable wavelength light source which applied the above-mentioned broadband light amplifier is explained below with reference to drawing 3 . This is the application which applied the magnification configuration of drawing 2 . In addition, the same element as drawing 2 attaches the same sign, and explanation of the overlapping part is omitted. The important section configuration of the broadband adjustable wavelength light source changes to the component of drawing 2 with the configuration of having added the adjustable wavelength optical filter 70 and the optical separator 85.
[0039] Connection connects the outgoing end of an optical switch 50 to the input edge of the adjustable wavelength optical filter 70, and the outgoing end of the adjustable wavelength optical filter 70 is connected to the input edge of the 1st optical isolator 11 through an optical separator 85. The output light of the broadband adjustable wavelength light source carries out outgoing radiation of what was separated spectrally with the optical separator 85. According to this, laser oscillation can be carried out as a result of forming the loop formation of a fiber ring (resonator). Moreover, oscillation wavelength can be set as the oscillation wavelength of arbitration by oscillating a loop gain on the wavelength which becomes one or more by alignment with the optical switch 50 which changes a magnification band to a C band and an L band, and the filter of the adjustable wavelength optical filter 70.
[0040] An optical switch 50 carries out change-over control of the optical path to oscillate a C band region so that 12s of lightwave signals which the C band light amplifier 120 outputs may be outputted, and it carries out change-over control of the optical path to oscillate an L band region so that 13s of lightwave signals which the component 200 of the L band light amplifier 320 outputs may be outputted.
[0041] The adjustable wavelength optical filter 70 is a wavelength filter controllable from the outside to arbitration, as an input, in response to 51s of outgoing radiation light from the outgoing end (output port) of an optical switch 50, it uses both the wavelength range of a C band and an L band as the wavelength filter in which adjustable is possible at least, and the component of the filter wavelength by which setting-out control was carried out carries out a passage output by the minimum passage loss. In addition, it is desirable to use the thing of a as steep band property (filter shape) as possible.
[0042] An optical separator 85 is separated spectrally and outputted to two paths in response to 70s of lightwave signals outputted from the above-mentioned adjustable wavelength optical filter 70. 86s of one spectral separation light is supplied to the input edge of the 1st optical isolator 11, they forms a loop formation, and the spectral separation light of another side is outputted to the exterior as 85s of outgoing radiation light of this broadband adjustable wavelength light source.
[0043] According to the configuration of drawing 3 mentioned above, the big advantage which can realize the broadband adjustable wavelength light source ranging from the C band to an L band region with a comparatively easy configuration is acquired.
[0044] In addition, the technical thought of this invention is not limited to the example of a concrete configuration of the gestalt of the above-mentioned implementation. Furthermore, the gestalt of the above-mentioned implementation may be transformed and applied by request. Below, the example of an application configuration is shown.
[0045] The example of a deformation configuration of a broadband light amplifier is shown in drawing 4 . In the broadband light amplifier which this shows to drawing 2 , although the 1st excitation light source 31 was the case where back excitation of the 1st Er addition optical fiber 21 was carried out, as shown in drawing 4 , it may change an arrangement location so that front excitation may be carried out, and can carry it out like ****.
[0046] Moreover, the example of a deformation configuration is shown in drawing 5 . In the broadband light amplifier which this shows to drawing 2 R> 2, although the 2nd excitation light source 32 was the case where front excitation of the 2nd Er addition optical fiber 22 was carried out, as shown in drawing 5 , it may change an arrangement location so that back excitation may be carried out, and can carry it out like ****.
[0047] Moreover, the example of a deformation configuration is shown in drawing 6 . In the broadband light amplifier which this shows to drawing 2 R> 2, further, the 1st excitation light source 31 changes an arrangement location so that front excitation of the 1st Er addition optical fiber 21 may be carried out, and the 2nd excitation light source 32 may change an arrangement location so that back excitation of the 2nd Er addition optical fiber 22 may be carried out, and it can carry it out like ****.
[0048] Moreover, the example of a deformation configuration is shown in drawing 7 . In the broadband light amplifier shown in drawing 2 R> 2, this is good also as a configuration equipped with the 2nd excitation light

source 32 and the 3rd excitation light source 33 so that the 2nd Er addition optical fiber 22 may be considered as the bidirectional excitation which carries out front excitation and back excitation, and it can be carried out like ****.

[0049] Moreover, the example of a deformation configuration is shown in drawing 8 . In the broadband light amplifier which this shows to drawing 7 R> 7, although the 1st excitation light source 31 was the case where back excitation of the 1st Er addition optical fiber 21 was carried out, as shown in drawing 8 , it may change an arrangement location so that front excitation may be carried out, and can carry it out like ****.

[0050] Next, the example of a deformation configuration of the broadband adjustable wavelength light source is shown in drawing 9 . In the broadband adjustable wavelength light source which this shows to drawing 3 , although the 1st excitation light source 31 was the case where back excitation of the 1st Er addition optical fiber 21 was carried out, as shown in drawing 9 , it may change an arrangement location so that front excitation may be carried out, and can carry it out like ****.

[0051] Moreover, the example of a deformation configuration is shown in drawing 10 . In the broadband adjustable wavelength light source which this shows to drawing 3 , although the 2nd excitation light source 32 was the case where front excitation of the 2nd Er addition optical fiber 22 was carried out, as shown in drawing 10 , it may change an arrangement location so that back excitation may be carried out, and can carry it out like ****.

[0052] Moreover, the example of a deformation configuration is shown in drawing 11 . In the broadband adjustable wavelength light source which this shows to drawing 3 , further, the 1st excitation light source 31 changes an arrangement location so that front excitation of the 1st Er addition optical fiber 21 may be carried out, and the 2nd excitation light source 32 may change an arrangement location so that back excitation of the 2nd Er addition optical fiber 22 may be carried out, and it can carry it out like ****.

[0053] Moreover, the example of a deformation configuration is shown in drawing 12 . In the broadband adjustable wavelength light source shown in drawing 3 , this is good also as a configuration equipped with the 2nd excitation light source 32 and the 3rd excitation light source 33, and can be carried out like **** so that the 2nd Er addition optical fiber 22 may be considered as the bidirectional excitation which carries out front excitation and back excitation.

[0054] Moreover, the example of a deformation configuration is shown in drawing 13 . In the broadband adjustable wavelength light source which this shows to drawing 12 , the 1st excitation light source 31 is the example of a configuration which changed the arrangement location, as front excitation of the 1st Er addition optical fiber 21 is carried out, and it can be carried out like ****.

[0055] Furthermore, the technical thought of this invention is not limited to the example of a concrete configuration of the gestalt of the above-mentioned implementation. For example, although it was the example which amplifies two C band light amplifiers 120 and the L band light amplifier 320 above, by request, it may have the light amplifier of three or more different bands, it may have a corresponding optical switch for an optical-path change, the series connection of each may be carried out, and the lightwave signal of two or more wavelength fields may be constituted possible [ magnification ] in predetermined. Moreover, the latter part of a broadband light amplifier may be added and equipped with the equalizer which carries out flattening of the amplification degree.

[0056] Next, in the time of L band magnification, the broadband light amplifier to which a means to improve that the signal to noise ratio (SNR) of 51s of outgoing radiation light outputted by amplifying deteriorates in connection with the ASE light by excitation light was added is explained below. Drawing 1515 is the example of an important section configuration of the broadband light amplifier whose improvement of signal to noise ratio was enabled at the time of L band magnification. Drawing 16 is the example of spectrum of the ASE light outputted from the 2nd Er addition optical fiber 22 when not specifying echo / transparency band of a WDM coupler, and drawing 17 is the example of spectrum of the ASE light outputted from a WDM coupler, when the WDM coupler set up so that a C band and an L band might be separated is used. With reference to these, it explains below.

[0057] As shown in drawing 1515 , to the component of drawing 5 mentioned above, the important section configuration of the broadband light amplifier of this invention deletes WDM coupler 32c, and changes with the configuration of the L band light amplifier 220 to which the 4th optical isolator 42 and the WDM coupler 40 were added instead. Other than the added element, since it is the same element as ****, it carries out and explanation is not required.

[0058] 52s of lightwave signals outputted from the C band light amplifier 120 mentioned above here is the output light which induced emission and spontaneous emmision superimposed. One induced emission is a part for induced emission Mitsunari based on 10s of incident light, and the spontaneous emmision of another side is a part for amplified spontaneous emmision (ASE) Mitsunari except a part for the induced

emission Mitsunari concerned.

[0059] The 2nd Er addition optical fiber 22 receives 52s of lightwave signals by input one end, 32s of excitation light from the 2nd excitation light source 32 is poured in from excitation supply one end, induced emission/spontaneous emmision is again performed inside the fiber concerned, and 22s of lightwave signals made into the magnification signal light and ASE light based on this is outputted. That is, as a result of being amplified on conditions which serve as Er addition optical fiber of the optimal conditions for amplifying an L band, both for a part for magnification signal Mitsunari by the induced emission of 10s of signal light of an L band band and other spontaneous emmision (ASE) Mitsunari do mixture superposition, and are outputted. ASE light is outputted also when 10s of incident light is non-input signal light. Here, it is accompanied by generating of the ASE light covering the broadband of an L band by the amount of spontaneous emmision Mitsunari from a C band.

[0060] The 4th optical isolator 42 prevents the lightwave signal which flows through the WDM coupler 40, and carries out supply impregnation of the 32s of the excitation light outputted from the 2nd excitation light source 32 to the 2nd Er addition optical fiber 22 through the WDM coupler 40. According to this, the unnecessary inhibition factor to the 2nd excitation light source 32 by 2 is [ 22s of lightwave signal components ] cancelable. In addition, when said same optical isolator is built in the outgoing radiation edge of 2nd excitation light source 32 self, this 4th optical isolator 42 is unnecessary.

[0061] Here, 22s of lightwave signals outputted from the 2nd Er addition optical fiber 22 is explained with reference to drawing 16 . At the time of a non-signal without 10s of incident light, 22s of lightwave signals altogether made into spontaneous emmision light based on excitation light occurs. The spectrum at the time of the non-signal of drawing 1616 A is the spectrum of the ASE light based on said spontaneous emmision light, and is crossed to the large wavelength band containing a C band and an L band. It becomes an unnecessary noise component that the spectrum of the ASE light based on this spontaneous emmision light always exists, considering the viewpoint which carries out optical amplification of the 10s of the incident light. That is, spontaneous emmision light is the noise factor in which the signal to noise ratio (SNR) in 51s of outgoing radiation light deteriorates.

[0062] Next, the WDM coupler 40 shown in drawing 15 is a WDM coupler equipped with the filter functional structure which carries out passage inhibition below of a C band wavelength field while using it as a multiplexing machine and using it. Namely, it functions as a multiplexing machine supplied to the 1st to the 2nd Er addition optical fiber 22 in response to 32s of excitation light outputted from the 2nd excitation light source 32 like the usual WDM coupler. And both for a part for magnification signal Mitsunari outputted to the 2nd from the 2nd Er addition optical fiber 22 and spontaneous emmision Mitsunari receive 22s of lightwave signals which carried out mixture superposition. the 1st — Mitsunari of an L band band — 1 (namely, a part for a part for magnification signal Mitsunari and ASE Mitsunari of an L band band) carries out a spectral separation output from an outgoing end side as 40s of lightwave signals for 22s per part — having — the 2nd — ASE Mitsunari of a C band band — the spectral separation output of 2 will be carried out from excitation supply one end for 22s per part. Consequently, as shown in the characteristic curve of drawing 17 B, the amount of [ below a C band field ] ASE Mitsunari carries out passage inhibition, and the spectrum component of the magnification band of an L band band carries out a passage output as it is, and outputs this as 40s of lightwave signals. 40s of this lightwave signal is outputted to the exterior as 51s of outgoing radiation light through the 3rd optical isolator 13.

[0063] Here, as an example of the WDM coupler 40, there is a well-known WDM coupler based on a dielectric multilayer gestalt. This structure reflects most light of the wavelength whose phase of the reflected wave from a multilayer pile and each thin film interface corresponds the thin film of the dielectric with which refractive indexes differ according to a regulation, and most others are formed so that it may be made to pass. According to this, the WDM coupler in which passage inhibition of below a C band wavelength field is possible is realizable by forming in predetermined conditions, such as a refractive index of the ingredient which constitutes the thickness of a dielectric multilayer, a number of layers, and a layer. According to the WDM coupler 40, as a result of removing a part for ASE Mitsunari below an unnecessary C band field in L band magnification, the advantage on which the signal to noise ratio of 51s of outgoing radiation light is improved relatively is acquired. therefore — more — low — noise L band optical amplification can be realized. Here, the example of spectrum of drawing 17 is shown and the spectrum of the ASE light outputted from the WDM coupler 40 is explained. The characteristic curve shown in drawing 17 A is the spectrum of the ASE light at the time of the non-signal outputted from the 2nd Er addition optical fiber 22 in the example of a configuration of drawing 5 mentioned above, and the characteristic curve shown in drawing 17 R>7B is the spectrum of the ASE light at the time of the non-signal outputted by passing the WDM coupler 40. These both spectrum comparison shows that clearance reduction of the

ASE light of the part below a C band field is carried out substantially, as shown in drawing 17 C. Therefore, the advantage on which signal to noise ratio is relatively improved corresponding to this clearance reduction will be acquired. When the example of a concrete numeric value showed said improvement, excitation reinforcement of the 1st excitation light source 31 is set to 90mW and the excitation reinforcement of the 2nd excitation light source 32 is assumed to be 60mW, the ASE light reinforcement which was +8.44dBm with the configuration of drawing 5 is stopped by the ASE light reinforcement of +3.71dBm with the configuration of drawing 15 . Therefore, as a result of stopping a 8.44-3.71=4.73dB unnecessary ASE light which is difference, the advantage on which the signal to noise ratio corresponding to this is improved will be acquired. This is effective especially when amplifying 10s of very small incident light. Moreover, since a floor noise is reduced when it applies to the measuring device of light etc. and incident light can be measured with a more sufficient precision, the advantage which becomes effective especially is acquired.

[0064] In addition, the configuration of above-mentioned drawing 15 is an example. for example, as shown in other examples of an internal configuration of the L band light amplifier 220 of drawing 18 , it is good also as an equipment configuration which is equipped with the two excitation light sources and excited from both directions, and signal to noise ratio improves like **** — having — more — low — noise L band optical amplification is realizable.

[0065] Moreover, you may realize by the equipment configuration considered as front excitation, back excitation, or bidirectional excitation also with the excitation technique of the C band light amplifier 120 shown in drawing 15 or drawing 18 .

[0066] Furthermore, the WDM coupler 40 shown in drawing 15 or drawing 18 is an example, and may be realized with the optical configuration which gained separate independence for the WDM coupler which is the independent multiplexing means, and the light filter component which can decrease [ which can decrease and can passage-prevent ] a C band wavelength field or below a C band wavelength field.

[0067]

[Effect of the Invention] This invention does so the effectiveness indicated by the following from the above-mentioned content of explanation. As the above-mentioned explanation was given, as a result of optical elements expensive as a configuration of a serial topology being reducible according to the broadband light amplifier by this invention, the advantage whose configuration components cost is reduced and is attained comparatively cheaply and simpler is acquired. Furthermore, the big advantage that the 2nd excitation light source 32 which the fiber length B of the 2nd Er addition optical fiber 22 which amplifies an L band is made cheaply short, and excites the 2nd Er addition optical fiber 22 can be managed with comparatively little excitation light source is also acquired. Furthermore, the same advantage as the above is acquired also in the broadband adjustable wavelength light source which applied this broadband light amplifier. moreover, the L band magnification equipped with the filtering function which carries out passage inhibition below of a C band wavelength field — setting — more — low — noise L band optical amplification is realizable. Therefore, the technical effectiveness of this invention is size and the economic effects on industry are also size.

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[Translation done.]

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## DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]
[Drawing 1] The conventional example of an important section configuration of a broadband light amplifier.
[Drawing 2] The example of an important section configuration of a broadband light amplifier of this invention.
[Drawing 3] The example of an important section configuration of the broadband adjustable wavelength light source of this invention.
[Drawing 4] The important section configuration of other broadband light amplifiers of this invention.
[Drawing 5] The important section configuration of other broadband light amplifiers of this invention.
[Drawing 6] The important section configuration of other broadband light amplifiers of this invention.
[Drawing 7] The important section configuration of other broadband light amplifiers of this invention.
[Drawing 8] The important section configuration of other broadband light amplifiers of this invention.
[Drawing 9] The important section configuration of other broadband adjustable wavelength light sources of this invention.
[Drawing 10] The important section configuration of other broadband adjustable wavelength light sources of this invention.
[Drawing 11] The important section configuration of other broadband adjustable wavelength light sources of this invention.
[Drawing 12] The important section configuration of other broadband adjustable wavelength light sources of this invention.
[Drawing 13] The important section configuration of other broadband adjustable wavelength light sources of this invention.
[Drawing 14] Magnification property drawing which makes possible optical amplification of a C band band and an L band band by the change of an optical switch of this invention.
[Drawing 15] The important section configuration of a broadband light amplifier whose improvement of signal to noise ratio was enabled at the time of L band magnification of this invention.
[Drawing 16] The example of spectrum of the ASE light outputted from the 2nd Er addition optical fiber when not specifying echo / transparency band of a WDM coupler.
[Drawing 17] The example of spectrum of the ASE light which has improved the noise ratio at the time of applying a WDM coupler when the WDM coupler set up so that the C band and L band of this invention might be separated is used.
[Drawing 18] Other examples of an internal configuration of an L band light amplifier of this invention.
[Description of Notations]
11 1st Optical Isolator
12 2nd Optical Isolator
13 3rd Optical Isolator
14 4th Optical Isolator
21 1st Er Addition Optical Fiber
22 2nd Er Addition Optical Fiber
31 1st Excitation Light Source
32 2nd Excitation Light Source
33 3rd Excitation Light Source
31c, 32c, 33c, 61, 62 WDM coupler
40 WDM Coupler
50 Optical Switch

70 Adjustable Wavelength Optical Filter
85 Optical Separator
100,120 C band light amplifier
200,320 L band light amplifier
220 L Band Optical Amplification Section (Component except C Band Light Amplifier 120)

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[Translation done.]

* NOTICES *

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1.This document has been translated by computer. So the translation may not reflect the original precisely.

2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

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DRAWINGS

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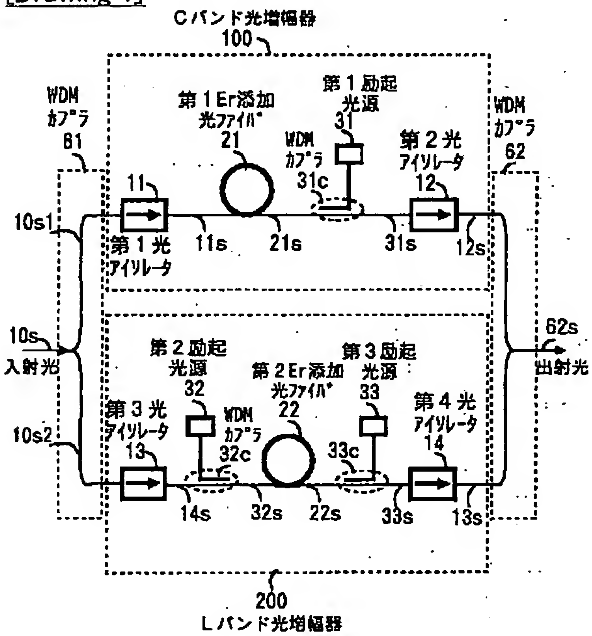
[Drawing 1]

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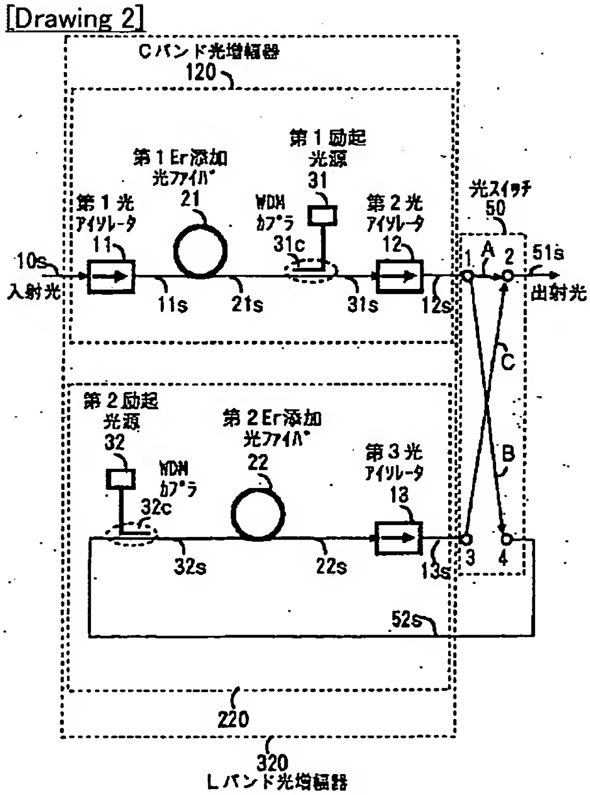

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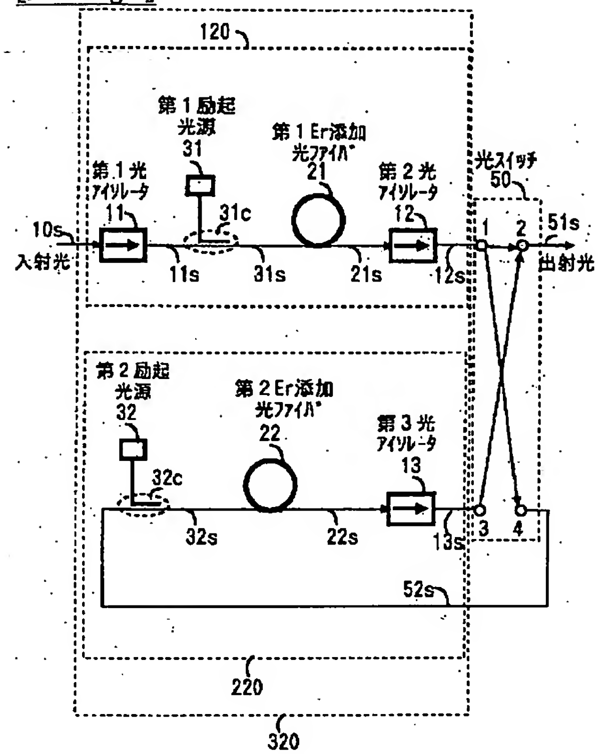


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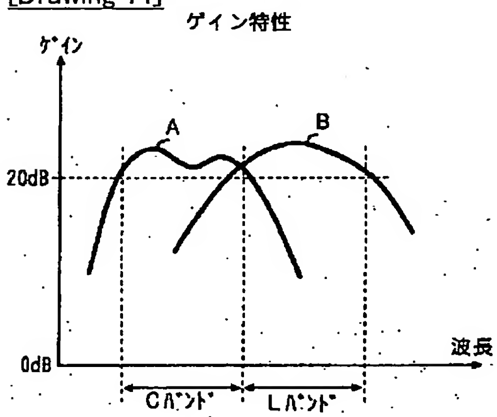


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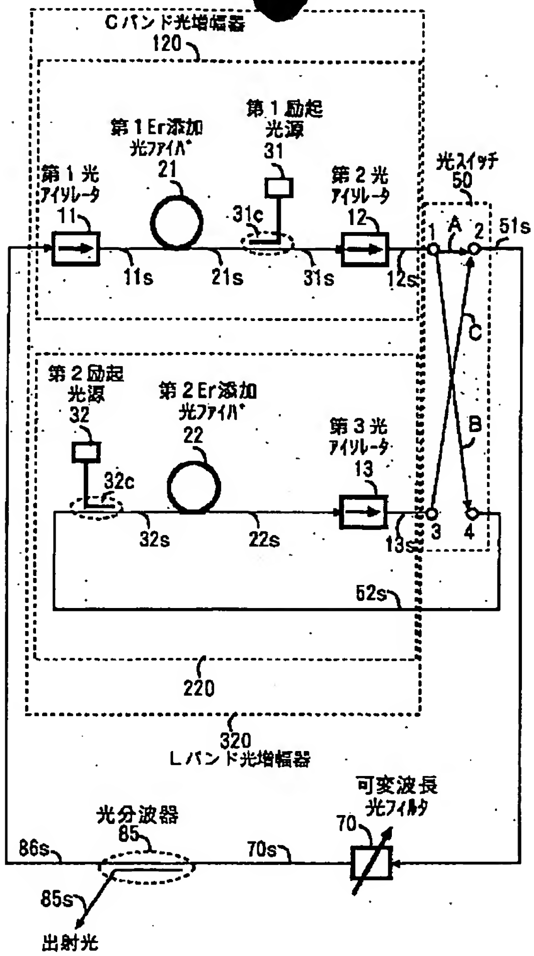


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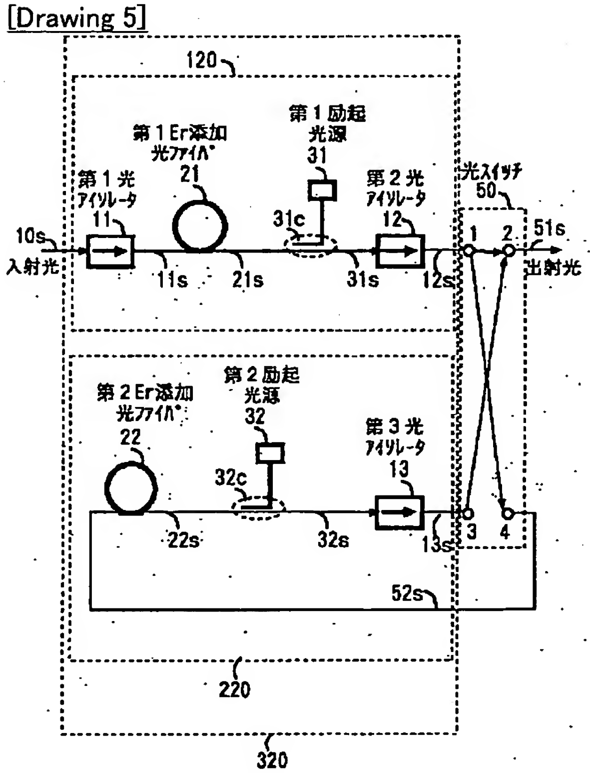


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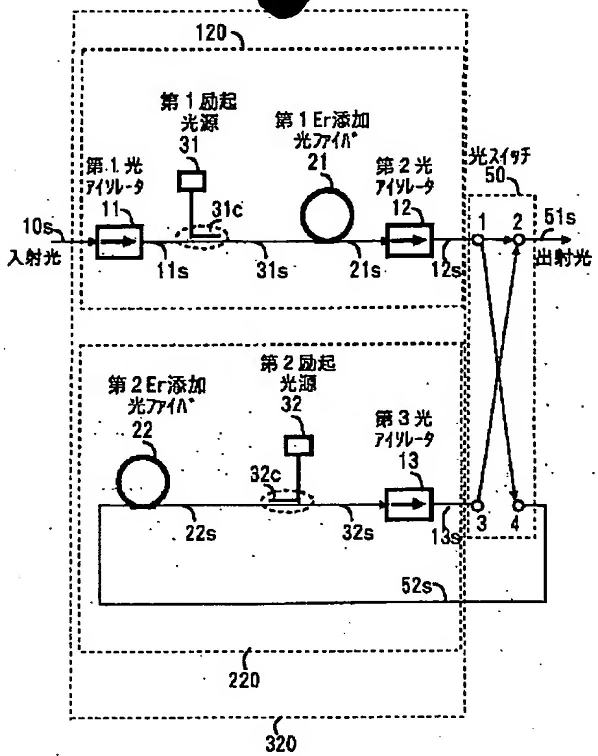


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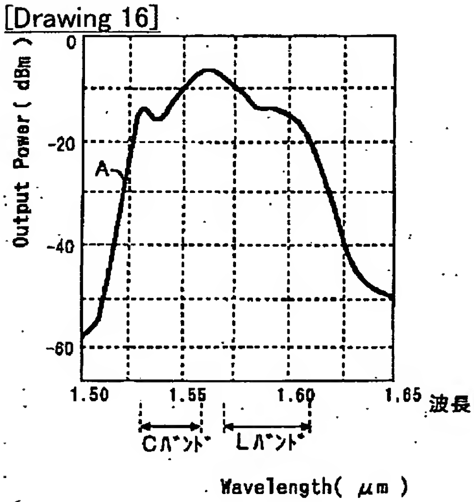


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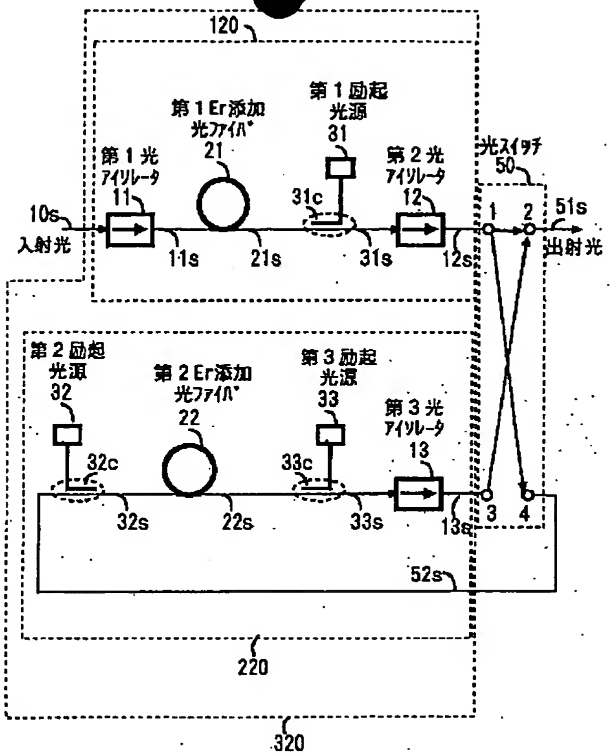


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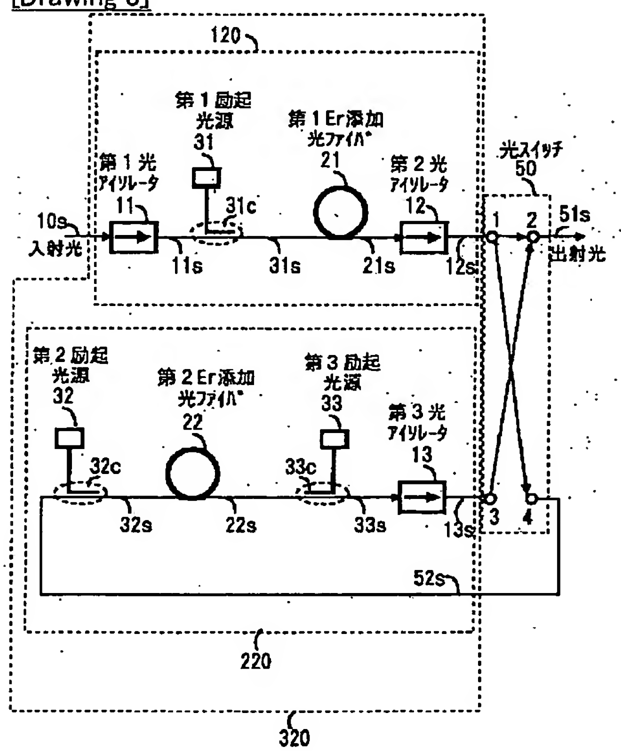


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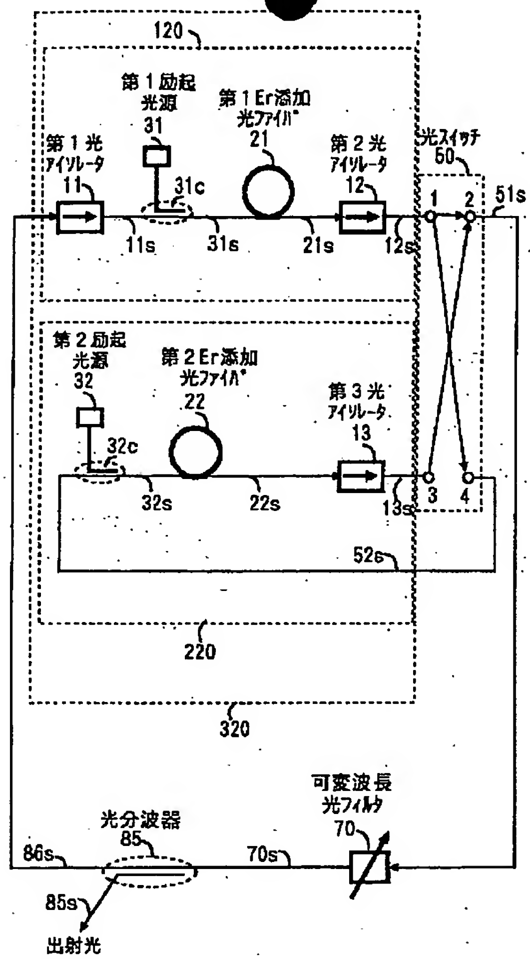


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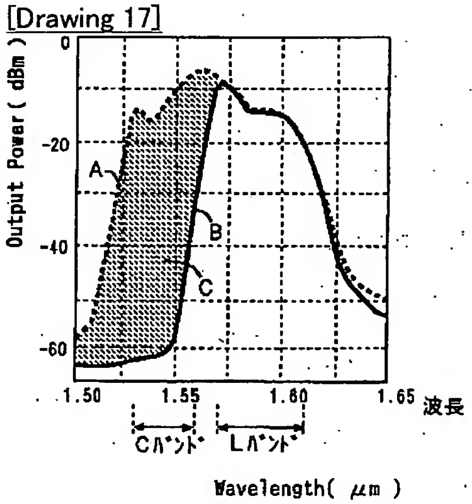


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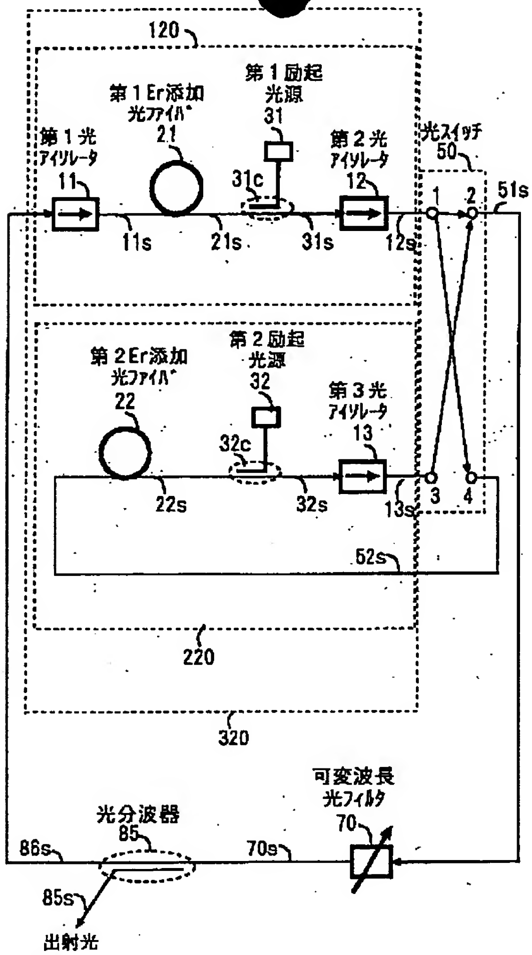
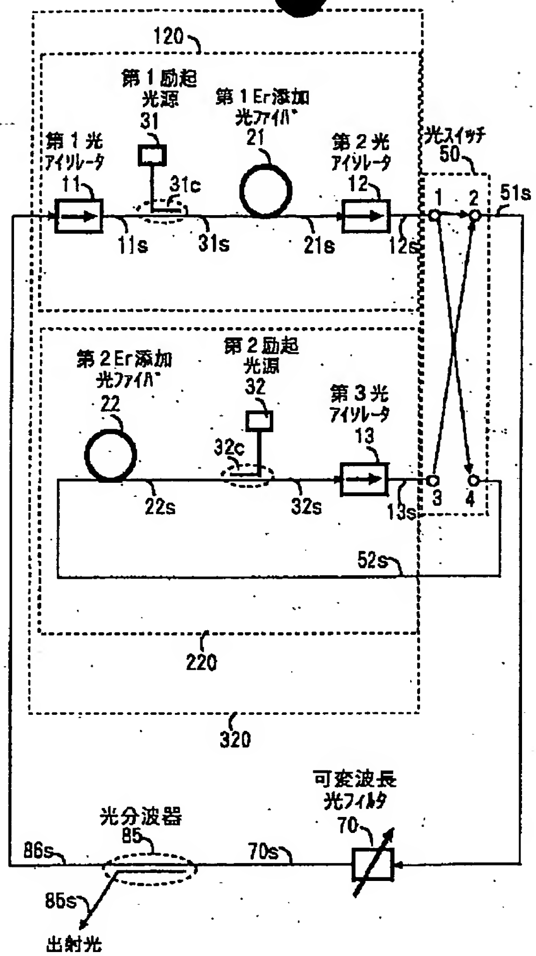


120
第１励起
光源
31
第１Er添加
光ﾌｧｲﾊﾞ
21
第１光
ｱｲｿﾚｰﾀ
11
31c
第２光
ｱｲｿﾚｰﾀ
12
光ｽｲｯﾁ
50
1
2
51s
11s
21s
31s
12s
第２励起
光源
32
第２Er添加
光ﾌｧｲﾊﾞ
22
第３光
ｱｲｿﾚｰﾀ
13
32c
22s
32s
13s
3
4
52s
220
320
可変波長
光ﾌｨﾙﾀ
70
光分波器
85
86s
70s
85s
出射光


[Drawing 11]


120
第１励起
光源
31
第１Er添加
光ファイバ
21
第１光
アイソレータ
11
31c
第２光
アイソレータ
12
光スイッチ
50
1
2
51s
11s
31s
21s
12s
第２Er添加
光ファイバ
22
第２励起
光源
32
第３光
アイソレータ
13
32c
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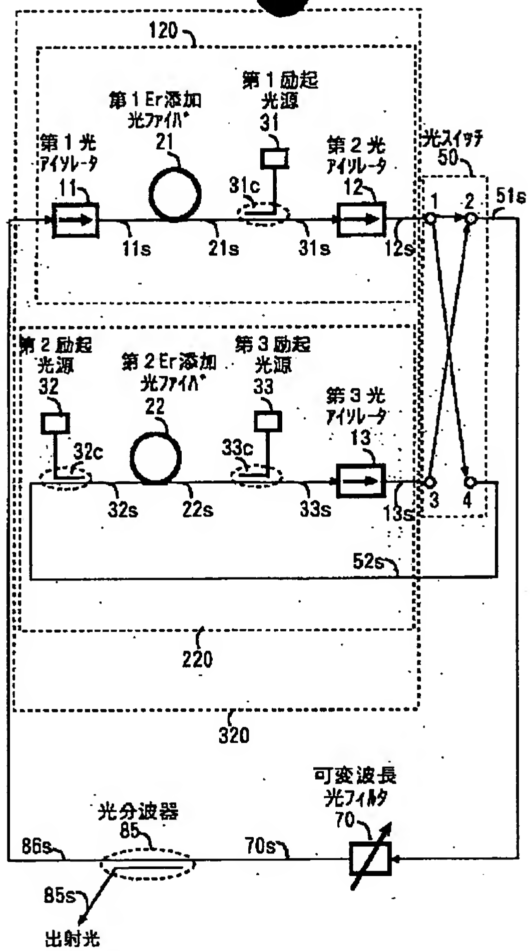
4
22s
32s
13s
52s
220
320
可変波長
光フィルタ
70
光分波器
85
86s
70s
85s
出射光

[Drawing 12]


120
第1Er添加
光ファイバ
21
第1励起
光源
31
第1光
アイソレータ
11
31c
第2光
アイソレータ
12
光スイッチ
50
1
2
51s
11s
21s
31s
12s
第2励起
光源
32
第2Er添加
光ファイバ
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光源
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第3光
アイソレータ
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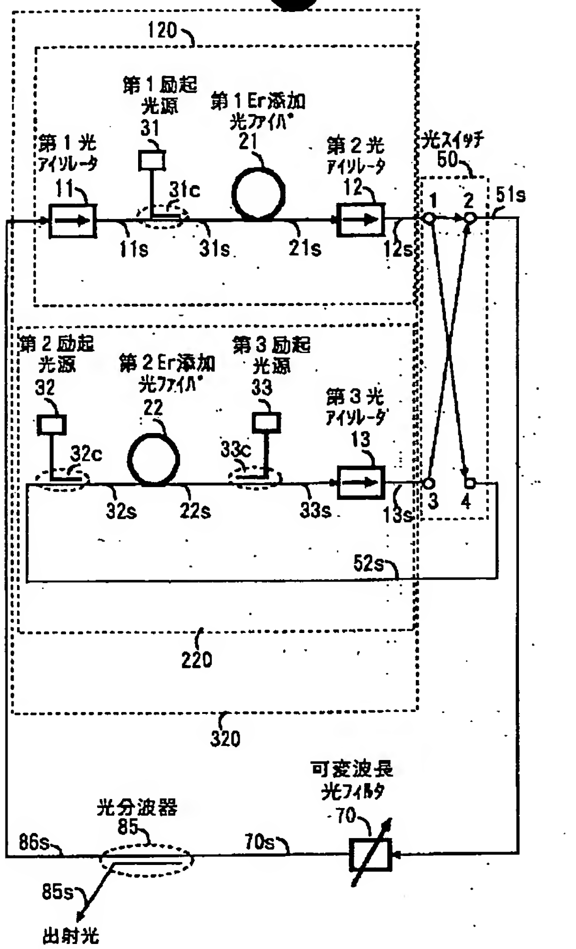
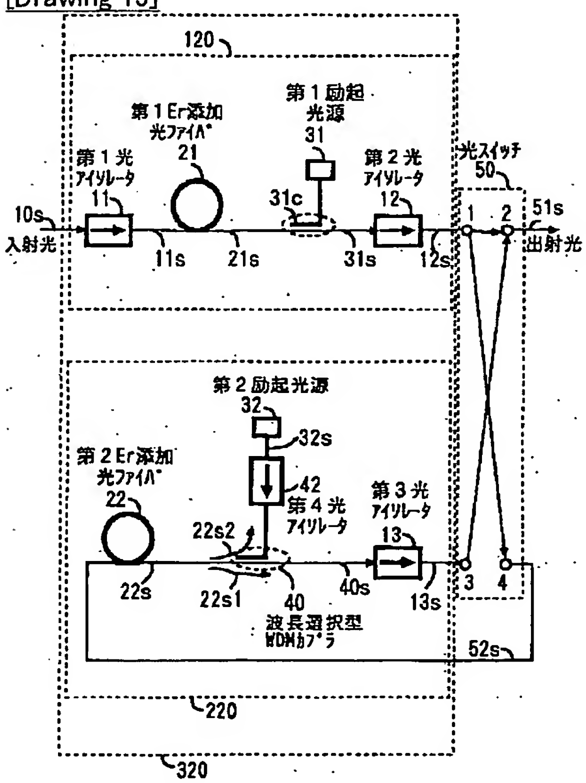
52s
220
320
可変波長
光フィルタ
70
光分波器
85
86s
70s
85s
出射光

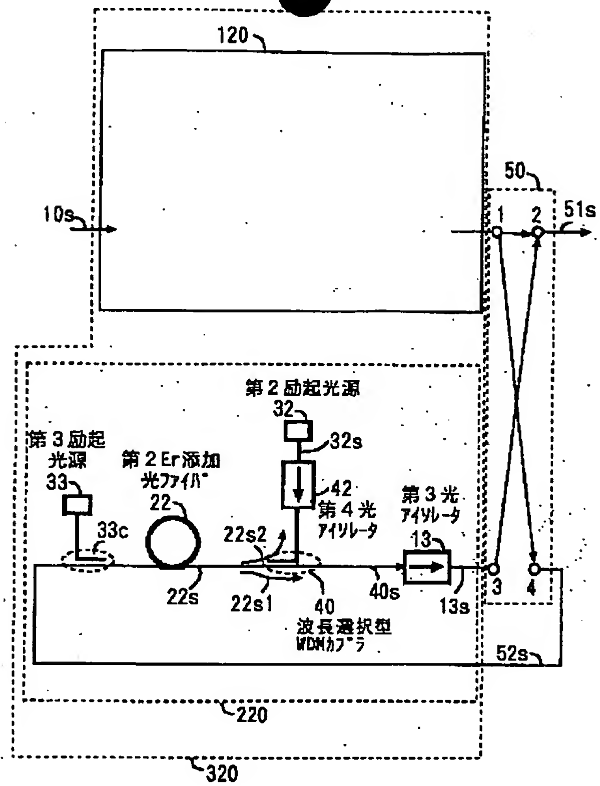
[Drawing 13]




[Drawing 15]




[Drawing 18]

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⑫公開特許公報（A）　平4-150088

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| H 04 B 10/16 | | | |
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| | | 8426-5K H 04 B 9/00 J | |

審査請求 未請求 請求項の数 4 （全8頁）

⑭発明の名称　光増幅システム

㉑特　願　平2-273413

㉒出　願　平2(1990)10月15日

⑫発明者　友藤　博朗　神奈川県川崎市中原区上小田中1015番地　富士通株式会社内

⑫発明者　西本　央　神奈川県川崎市中原区上小田中1015番地　富士通株式会社内

⑪出願人　富士通株式会社　神奈川県川崎市中原区上小田中1015番地

⑭代理人　弁理士　松本　昂

明　細　書

1．発明の名称

光増幅システム

2．特許請求の範囲

1．低雑音な前段の光増幅器(1)と、

該前段の光増幅器(1)よりも高雑音で且つ飽和出力が高い後段の光増幅器(2)とを備えたことを特徴とする光増幅システム。

2．請求項1に記載の光増幅システムにおいて、

前段の光増幅器(1)と後段の光増幅器(2)の間に光アイソレータ(3)を設けたことを特徴とする光増幅システム。

3．請求項1に記載の光増幅システムにおいて、

前段の光増幅器(1)は後方向励起方式の光ファイバ増幅器とし、

前段の光増幅器(1)と後段の光増幅器(2)の間に第1の光アイソレータ(3)を設け、

上記後段の光増幅器(2)の出力側に第2の光アイソレータ(4)を設けたことを特徴とする光増幅システム。

4．請求項1に記載の光増幅システムにおいて、

前段の光増幅器(1)と後段の光増幅器(2)の間に第1の光アイソレータ(3)を設け、

上記後段の光増幅器(2)の出力側に第2の光アイソレータ(4)を設け、

上記前段の光増幅器(1)の入力側に第3の光アイソレータ(5)を設けたことを特徴とする光アイソレータ。

3．発明の詳細な説明

目　次

発明の効果

## 概　要

光増幅システムに関し、

低雑音で且つ高飽和出力のシステムを実現することを主目的とし、

例えば、低雑音な前段の光増幅器と該前段の光増幅器よりも高雑音で且つ飽和出力が高い後段の光増幅器とを備えて構成する。

## 産業上の利用分野

本発明は光増幅システムに関する。

近年、光増幅器の研究が盛んに行われている。光増幅器を送信側の直後においてポストアンプとして用い、受信側の受光素子の直前においてプリアンプとして用い、あるいは光伝送路の途中において中継器として用いることにより、伝送距離の長距離化・受信感度の改善が可能になる。ここで、光増幅器を中継器として用いる場合、低雑音で且つ飽和出力が高いシステムが要求され、また、プリアンプとして用いる場合、低雑音なシステムが要求される。

## 従来の技術

従来の光増幅システムの構成例を第10図により説明する。同図(a)に示されたシステムは、半導体光増幅器102の入力側及び出力側にそれぞれ光アイソレータ101，103を設けて構成されている。また、同図(b)、(c)において、101，103は光アイソレータ、104は合波器、105はEr等の希土類元素がドープされた光ファイバ等からなる増幅媒質、106は励起光源である。このように、従来構成においては、単一の光増幅器あるいは増幅媒質を用いて、光増幅器あるいは増幅媒質の入力側及び出力側に光アイソレータが設けられている。

## 発明が解決しようとする課題

従来のように単一の光増幅器あるいは増幅媒質を用いている場合、低雑音であると飽和利得が小さくなり、これとは逆に飽和利得が大きいと高雑音になる傾向があった。このように、従来技術によると、低雑音で且つ高飽和出力のシステムを実現することが困難であった。

また、多重反射が生じると、受信感度の劣化、光増幅器自身の発振を引き起こすので、光増幅システムを構築する場合には光アイソレータを用い、反射光を防ぐ必要があり、光アイソレータの効果的な使用が要求される。

更に、光増幅器あるいは増幅媒質の入力側に光アイソレータや励起用の光学部品（合波器等）をおくと、その損失に起因してS／N比が劣化することがあり、これに対処することも要求される。

本発明の目的は低雑音で且つ高飽和出力の光増幅システムを実現することである。

本発明の他の目的は、高利得動作時に顕著になる多重反射の影響を効果的に防ぐことができる光増幅システムの提供である。

## 課題を解決するための手段

第1図は本発明の光増幅システムの第1構成を示す図である。このシステムは、低雑音な前段の光増幅器1と、前段の光増幅器1よりも高雑音で且つ飽和出力が高い後段の光増幅器2とを備えて構成される。

第2図は本発明の光増幅システムの第2構成を示す図である。このシステムは、前段の光増幅器1と後段の光増幅器2の間に光アイソレータ3を設けて構成される。

第3図は本発明の光増幅システムの第3構成を示す図である。このシステムは、前段の光増幅器1と後段の光増幅器2の間に第1の光アイソレータ3を設け、後段の光増幅器2の出力側に第2の光アイソレータ4を設けて構成される。前段の光増幅器1は後方向励起方式の光ファイバ増幅器である。

第4図は本発明の光増幅システムの第4構成を示す図である。このシステムは、前段の光増幅器1と後段の光増幅器2の間に第1の光アイソレー

タ3を設け、後段の光増幅器2の出力側に第2の光アイソレータ4を設け、前段の光増幅器1の入力側に第3の光アイソレータ5を設けて構成される。

作　　用

本発明の第1構成における作用を説明する。光増幅器の静特性は、近似的には以下のレート方程式に従う。

$$\frac{dP_s}{dz} = -\alpha P_s(z) + k\{N(z) - N_G\} P_s(z) \quad \cdots (1)$$

$$\frac{\partial N(z)}{\partial t} = \gamma - \frac{N(z)}{\tau_s} - k(N(z) - N_G)\frac{P_s(z) + P_N(z)}{h\nu S} \quad \cdots (2)$$

$$\frac{dP_N}{dz} = -\alpha P_N(z) + k\{N(z) - N_G\} P_N(z) + C\frac{N(z)}{\tau_s}, \quad \cdots (3)$$

ここで、zは光の進行方向の変位、N（z）は反転分布密度、$P_s$（z）は信号光強度、$P_N$（z）は自然放出光強度（雑音に相当し、$P_N$（0）＝0）、$\tau_s$、Cは係数、tは時間である。

(2)式において$\frac{\partial N}{\partial t} = 0$，$P_s(z) \gg P_N(z)$であるから、

$$N(z) = \frac{\gamma + \dfrac{kN_G P_s(z)}{h\nu S}}{\dfrac{1}{\tau_s} + \dfrac{kP_s(z)}{h\nu S}} \quad \cdots (2)'$$

となり、これを(1)式に代入すると、

$$\frac{dP_s}{dz} = -\alpha P_s + \frac{k}{1 + P_s(z)/P_{sat}}(\gamma\tau_s - N_G)P_s(z) \quad \cdots (1)'$$

$$P_{sat} = h\nu S / k\tau_s \quad \cdots (4)$$

が得られる。一方、(1)式から、

$$\frac{dP_s}{dz} = \{-\alpha + k(N(z) - N_G)\} P_s(z)$$

となるから、

$$G = \int_0^L \{-\alpha + k(N(z) - N_G)\} dz \quad \cdots (5)$$

$$= \int_0^L \left(-\alpha + k\frac{\gamma\tau_s - N_G}{1 + P_s/P_{sat}}\right) dz$$

$$\fallingdotseq \int_0^L (-\alpha + k(\gamma\tau_s - N_G)) dz \quad \cdots (6)$$

となる。尚、(6)式は$P_s(z) \ll P_{sat}$のときのものである。ここで、kは比例係数、Lは増幅作用長（光増幅器の長さ）、$\tau_s$は反転分布寿命、$\alpha$は（導波路の）損失、Sは増幅器の断面積（半導体光増幅器の場合：活性層の断面積、ファイバ光増幅器の場合：モードフィールドの占める面積）、$N_G$は利得に貢献しない反転分布密度、$\gamma$はポンピング率、hはプランク定数、$\nu_s$は信号光周波数、$P_{sat}$は飽和出力である。

(4)式より飽和出力$P_{sat}$を大きくするには、利得と反転分布とを結びつけるkを小さくすればよいことがわかる。ただし、kとSに関係が有る場合は、k／Sを小さくしつつkを小さくする必要がある。

しかし、kを小さくすることは、利得が(5)式で決まるので、反転分布が効率的に利得に貢献しないことになる。そのため、同じ利得を得る場合、kを小さくすると反転分布の量がふえることになる。光増幅器の雑音は反転分布の量が大きくなるに従って増加するため、比例係数kを小さくして飽和出力$P_{sat}$を大きくすると、雑音が増大することになる。(3)式は、光増幅器の各部分で雑音が$C\frac{N(z)}{\tau_s}$発生し、それが、その発生点から、光増幅器の出力端に達するまでの利得で増幅されることを示している。利得が大きい場合、光増幅器の光入射側（z＝0）に近い方で発生する雑音が特に影響が大きい。このため、kが大きい前段の光増幅器1とkが小さい後段の光増幅器2とを組み合わせて用いて、低雑音な光増幅器1の飽和出力付近まで光増幅器でまず増幅すると、同じ利得を前段の光増幅器1の代わりに後段の光増幅器2を用いる場合よりも雑音が低くなる。

半導体光増幅器では、k＝$\xi g_0$、光ファイバ

増幅器では、$k=\sigma SM$とかける。尚、$\xi$は光閉じ込め係数、$g_0$は微分利得、$\sigma$は誘導放出の有効断面積、Sは増幅器の断面積、Mは励起イオンと信号光との重なり度を表す。

このように本発明の第1構成によると、低雑音で且つ高飽和出力の光増幅システムの実現が可能になる。

次に、本発明の第2構成又は第4構成における作用を説明する。光増幅器の両端に反射点が存在する場合、信号光の大きさ1に対して、戻り光の大きさは、光増幅器の利得G及び反射点での反射率Rを用いて$G^2R^2$で表されるから、光増幅器の利得が大きくなるに従って影響が大きくなる。また、この影響による感度の劣化PPは(7)式で与えられる。

$$PP=-5\mathrm{LOG}\left(1-144\left(N_{sp}h\nu B/P_{IN}+G^2R^2\right)\right) \quad \cdots(7)$$

ここで、$N_{sp}$は自然放出係数、hはプランク定数、$\nu$は信号光の周波数、Bは光増幅器の帯域（又は光フィルタの帯域）、$P_{IN}$は光入力信号の平均値である。

例えば第10図(a)等に示された従来構成において、光アイソレータ101，103の反射率をR、光増幅器102の利得をGとすると、多重反射の大きさは$G^2R^2$となる。受信感度の劣化は多重反射の大きさで決まるので、利得Gが大きくなると、反射率Rの低減を図る必要が生じる。これに対して、本発明の第2構成又は第4構成は次のような優位性を有している。いま、第2図において、前段の光増幅器3から入射側を見たときの反射率を$R_1$とし、後段の光増幅器4から出射側を見たときの反射率を$R_2$とし、光アイソレータ5の反射率をRとし、例えば光増幅器3，4の利得をそれぞれ$\sqrt{G}$とすると、この光増幅システムにおけるトータルの利得は従来構成における場合と同様Gとなるが、多重反射の大きさは$R_1\cdot R\cdot G$、$R_2\cdot R\cdot G$となり、本発明によると利得の多重反射への影響を小さくすることができることがわかる。

本発明の第4構成（第4図）にように、光増幅システムの両端に光アイソレータ6，7を追加すると、$R_1$，$R_2$が光アイソレータの反射率で決まり、光アイソレータがない場合よりも更に反射率を下げることができるので、より大きな利得においても多重反射の影響を受け難くなる。

次に、本発明の第3構成における作用を説明する。従来構成において、大きい利得Gの光増幅器の前段に損失$\eta_1$の光アイソレータ等の光学部品が配置されている場合のS／N比は次のように表される。

$$\frac{S}{N}=\frac{(N_1\eta_1 Ge)^2}{4n_{sp}N_1\eta_1 e^2G(G-1)Bn+4n_{sp}^2e^2(G-1)^2Bn\Delta f}$$

$$\fallingdotseq\frac{N_1^2\eta_1^2}{4n_{sp}N_1\eta_1 Bn+4n_{sp}^2Bn\Delta f}\quad(\because G\gg1)\cdots(8)$$

ただし、G（≫1）；光増幅器の利得、

$\eta_1$（＜1）；入力側の損失、

$N_1$；入力光子数、

$n_{sp}$；自然放出係数、

$\Delta f$；光フィルタ帯域、

Bn；受信器の帯域

一方、本発明の第3構成において、利得$G_1$の前段の光増幅器と利得$G_2$の後段の光増幅器の間に損失$\eta_1$の光アイソレータ等の光学部品が設けられている場合におけるS／N比は次のように表される。尚、$G_1\cdot G_2=G$とする。

$$\begin{aligned}\frac{S}{N}=&(N_1G_1G_2\eta_1 e)^2/\{4n_{sp}e^2N_1G_1(G_1-1)G_2^2\eta_1^2Bn+\\&4n_{sp}^2e^2(G-1)^2\eta_1^2G_2^2Bn\Delta f+\\&4n_{sp}e^2(N_1G_1\eta_1)G_2(G_2-1)Bn+\\&4n_{sp}^2e^2(G_2-1)^2Bn\Delta f\}\\\fallingdotseq&N_1^2\eta_1^2/(4n_{sp}N_1Bn\eta_1^2+4n_{sp}^2\eta_1^2Bn\Delta f+\\&4n_{sp}N_1Bn\frac{\eta_1}{G_1}+4n_{sp}^2\frac{1}{G_1^2}Bn\Delta f)\\=&N_1^2/\{4n_{sp}N_1Bn\left(1+\frac{1}{G_1\eta_1}\right)+\\&4n_{sp}^2Bn\Delta f\left(1+\frac{1}{(G_1\eta_1)^2}\right)\}\cdots(9)\end{aligned}$$

本発明の第3構成による場合、前段の光増幅器の利得$G_1$をある程度の大きさ以上（例えば10

dB以上）にすれば、後段の光増幅器で加わる雑音は無視することができる程度になる。更に、本構成によると、光増幅器の入射側に光アイソレータ等の光学部品がないので、入力光強度は従来構成による場合よりも大きくなり、S／N比は大きく改善されることになる。具体的には、(8)式及び(9)式を比較すると、$1/\eta_1$倍から$1/\eta_1{}^2$倍程度になる。

一方、光増幅器を用いる場合、多重反射の影響に注意する必要もある。このため、通常、他の光学部品やレーリ散乱による戻り光を防ぐため、光増幅器の両端に光アイソレータを入れるかあるいは反射率を低減するため光部品間はスプライスにより接続する。

光増幅器の入射側の光アイソレータを取り去る場合、多重反射の影響が問題となる。このため、前段の光増幅器の利得を、回線切断時に光増幅器が光発振器となって発振したりQスイッチ動作をしたり、通常動作状態で多重反射による受信感度の劣化を生じない程度に抑えて、後段の光増幅器は光アイソレータを両側に配することで、多重反射による受信感度劣化の影響を従来のように抑えつつ、入力信号を弱めていた原因を取り除くことができる。

実　施　例

以下本発明の実施例を説明する。

本発明の第1構成を実施する場合、前段の光増幅器と後段の光増幅器を差別化するためには、微分利得が異なるあるいは光閉じ込め係数が異なるような構造や組成の組合せを持つものを使用すればよい。この例を以下に示す。

①通常の活性層を有する半導体光増幅器（前段）と不純物をドープした活性層を有する半導体光増幅器（後段）を用いる。この場合、不純物をドープした活性層を持つ半導体光増幅器の方が微分利得が低くなる。

②通常の活性層を有する半導体光増幅器と量子井戸構造を導入した活性層を有する半導体光増幅器を用いる。

③量子井戸構造を導入した活性層を有する半導体光増幅器（井戸数が少ない）と量子井戸構造を導入した活性層を有する半導体光増幅器（井戸数が多い）を用いる。

これらの組合せの半導体光増幅器をモノリシックに同一基板上に一体化して作成してもよいし、別個に作成して光結合をとってもよい。

前段の光増幅器及び後段の光増幅器として光ファイバ増幅器を用いる場合には、Er等の希土類元素のドープ領域を異ならせることにより微分利得係数を異ならせることができる。即ち、前段の光増幅器としては、第5図(a)に示すように、モードフィールド径に対してドープ領域が比較的広い光ファイバ増幅器を用い、後段の光増幅器としては、同図(b)に示すように、モードフィールド径に対してドープ領域が比較的狭い光ファイバ増幅器を用いる。

前段の光増幅器として光ファイバ増幅器を用い、後段の光増幅器として半導体光増幅器を用いることができる。半導体光増幅器の飽和出力は大きく、光ファイバ増幅器は低雑音である。

第6図は本発明の第1実施例を示す光増幅システムのブロック図である。この例では、前段の光増幅器1及び後段の光増幅器2として光ファイバ増幅器が用いられている。前段の光増幅器1において、11は励起光源、12はEr等の希土類元素をドープしてなる増幅媒質、13は増幅すべき信号光と励起光を合波して増幅媒質12に入射させるための合波器である。後段の光増幅器2において、21は励起光源、22は増幅媒質、23は励起光を増幅媒質22の信号光入力側から入射させるための合波器である。

この例では、出力光強度が一定に保たれるように、AGC部30が設けられている。AGC部30において、31はモニタ用の光信号を分岐するための分岐器、32は分岐された光のうち信号光のみ通し自然放出光や励起光を除去するための光フィルタ、33は光フィルタ32を透過した光を電気信号に変換する受光器、34は受光器33の受光レベルが一定に保たれるように励起光源21

を制御する制御回路である。このようなAGC系を構成することにより、入力信号レベルにかかわらず常に一定の光出力を得ることができる。

この例では、前段の光増幅器1を後方向励起方式で構成し、後段の光増幅器2を前方向励起方式で構成しているが、後段の光増幅器を後方向励起方式で構成してもよい。本実施例によると、前段の光増幅器の入力損失を減少させることができ、システム全体のS／N比を向上させることができる。また、利得を高く設定したときに、多重反射の影響が少ない。

回線切断時に光増幅器が光発振器となって発振したり、Qスイッチ動作をしたり、通常動作状態で多重反射による受信感度の劣化がなければ、光アイソレータ4を取り除くことができる。

第7図は本発明の第2実施例を示す光増幅システムのブロック図である。この例では、前段の光増幅器1及び後段の光増幅器2として半導体光増幅器を用いている。14，24は半導体レーザ型に構成された半導体光増幅器、15，25はそれぞれ半導体光増幅器14，24に駆動電流を供給する駆動回路である。AGC部40において、41は信号光のみを透過し自然放出光や励起光を除去するための光フィルタ、42は光フィルタ41の透過光からモニタ用の光信号を分岐するための分岐器、43は分岐光を電気信号に変換する受光器、44は受光器43の受光レベルが一定になるように駆動回路25を制御する制御回路である。

この実施例によると、前段の光増幅器1及び後段の光増幅器2をモノリシックに基板上に形成することもできるので、前実施例と比較して装置の小型化が可能である。本実施例においても、前実施例における条件と同一の条件下で光アイソレータ4を取り除くことができる。

第8図は本発明の第3実施例を示す光増幅システムのブロック図である。この例では、前段の光増幅器1として前方向励起型の光ファイバ増幅器を用い、後段の光増幅器2として半導体光増幅器を用い、これまでの実施例と同様AGC部30を設けている。

第9図は本発明の第4実施例を示す光増幅システムのブロック図である。この例は本発明の第4構成の実施例に相当する。即ち、本発明の第4構成において、光アイソレータ4から出力される光強度が一定に保たれるように、AGC部30を設け、後段の光増幅器2の利得を制御するようにしたものである。

本発明の実施例において、AGCを後段の光増幅器でかけているのは、出力の高い状態で次段の増幅器に入る方がS／N比がよいからである。

発明の効果

以上説明したように、本発明によると、低雑音で且つ高飽和出力の光増幅システムの実現が可能になるという効果を奏する。また、高利得動作時に顕著になる多重反射の影響を効果的に防ぐことができるようになるという効果もある。その結果、従来よりも低い入力でも光増幅システムにおいて高いS／N比を得ることができ、伝送距離を飛躍的に拡大することができるようになる。

4．図面の簡単な説明

第1図乃至第4図はそれぞれ本発明の第1乃至第4構成を示す図、

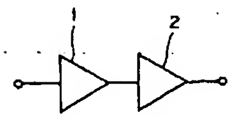
第5図は希土類元素のドープ領域の説明図、

第6図乃至第9図はそれぞれ本発明の第1乃至第4実施例を示す光増幅システムのブロック図、

第10図は従来技術の説明図である。

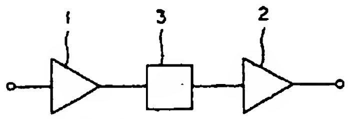
1…前段の光増幅器、
2…後段の光増幅器、
3，4，5…光アイソレータ。

出願人：　富士通株式会社
代理人：　弁理士　松本　昴



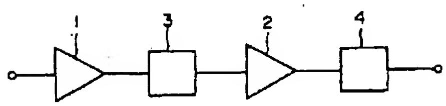

第1構成を示す図

第 1 図



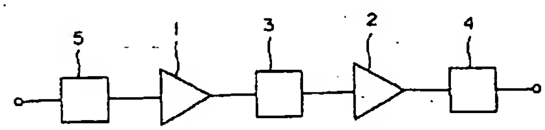

第2構成を示す図

第 2 図



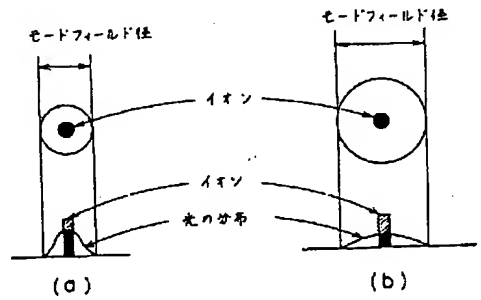

第3構成を示す図

第 3 図



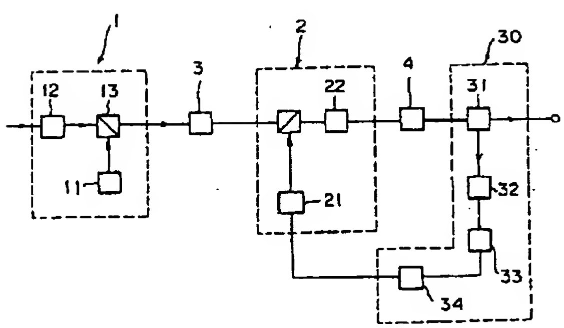

第4構成を示す図

第 4 図



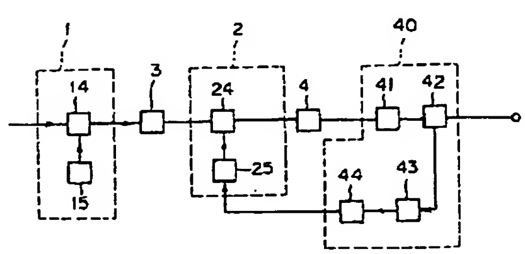

希土類元素のドープ領域の説明図

第 5 図



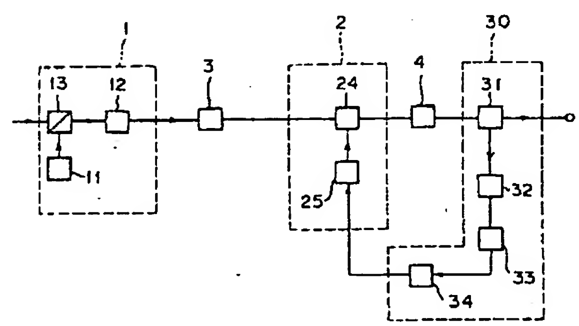

第1実施例図

第 6 図



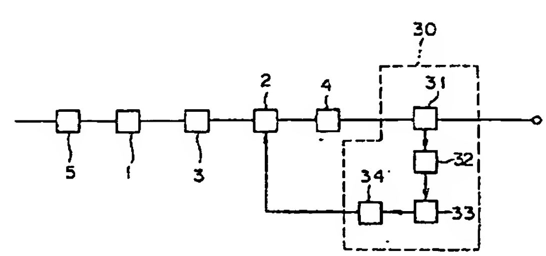

第2実施例図

第 7 図



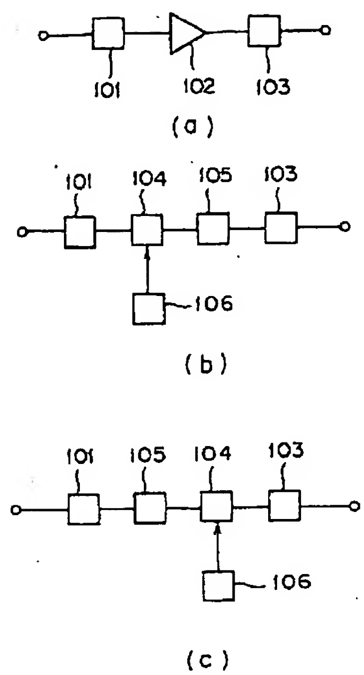

第3実施例図

第 8 図




第4実施例図

第 9 図




従来例図

第10図